Exhibit 7

Report on South Carolina Congressional Districts

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Contents

1 Background and qualifications

I am a Professor of Mathematics and a Senior Fellow in the Jonathan M. Tisch College of Civic Life at Tufts University. At Tisch College, I am the director and principal investigator of an interdisciplinary research lab focused on geometric and computational aspects of redistricting. My areas of research and teaching include the structure of census data, the history of the U.S. Census, the design and implementation of randomized algorithms for generating districting plans, and the analysis of redistricting more broadly. I was recently awarded a major grant from the National Science Foundation to study *Network Science of Census Data*.

I am compensated at $300/hour for my work in this case. I have previously written reports and provided testimony by deposition, a hearing, or at trial in North Carolina, Pennsylvania, Wisconsin, and Alabama, as well as for the challenge in this case to certain South Carolina House of Representatives districts.[1] A full copy of my CV is attached to this report.

1.1 Assignment

I have been asked to examine the Congressional districts enacted in South Carolina (Enacted2022), together with the maps from the previous census cycle (Previous2012), alternative maps presented during the legislative process (notably the map submitted with the Harpootlian Amendment, which I have denoted Harpootlian) as well as those by the South Carolina NAACP (SC-NAACP1, SC-NAACP2), the League of Women Voters of South Carolina (LWVSC), and by other members of the public (Foster, Harrison, Muscatel, Sukovich, and Roberts). The eleven maps under consideration are shown on the following two pages.

In comparing these maps, my focus is to assess the state's enacted plan. My analysis will consider the possibility of excessively race-conscious line-drawing, especially noting when traditional districting principles have been undermined in a manner that results in "cracking"—splitting communities and dispersing their voters over multiple districts. I will consider whether this cracking ultimately leads to discernible vote dilution for the Black population of South Carolina.

All work in this report was completed by me and by research assistants working under my direct supervision.

1.2 Materials

Materials consulted in the preparation of this report include the following.

- A major source is Census data, primarily the Decennial Census releases (i.e., the PL 94-171). Other data products from the Census Bureau, including the American Community Survey and the TIGER/Line shapefiles, were also used.

- For priorities and criteria, I consulted the publications by the South Carolina House of Representatives Redistricting Ad Hoc Committee on *2021 Guidelines and Criteria for Congressional and Legislative Redistricting*, and the corresponding publication for the Senate. These are available at [5, 8].

- The state's Congressional plan and numerous publicly submitted alternative plans are available on the state's website [6, 9].

- Community of interest testimony was collected at public meetings and is recorded on the state's website [7, 10].

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[1]*NC League of Conservation Voters, et al. v. Hall, et al.* No. 21-cvs-500085 (Wake Cnty. Sup. Ct. 2021); *Carter v. Chapman*, No. 7 MM 2022, 2022 WL 702894 (Pa. Mar. 9, 2022); *Johnson v. Wis. Elections Comm'n*, No. 2021AP1450-OA, 2022 WL 621082 (Wis. Mar. 3, 2022); *Milligan, et al. v. Merrill, et al.*, Case No. 2:21-cv-01530-AMM and *Thomas, et al. v. Merrill, et al.*, Case No. 2:21-cv-01531-AMM (N.D. Ala. 2021).

Congressional Maps
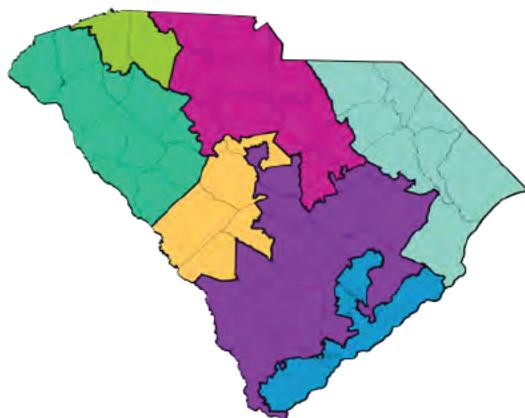
Enacted2022

Previous2012
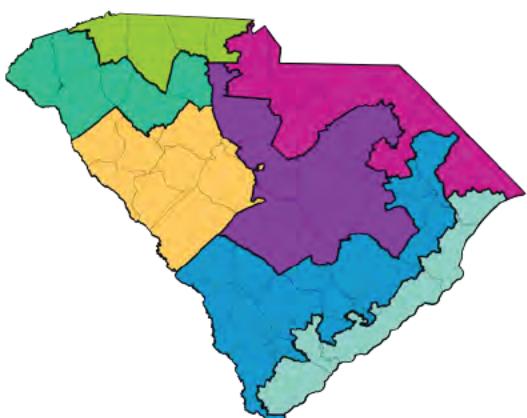
SC-NAACP1

SC-NAACP2

Harpootlian

LWVSC

① ② ③ ④ ⑤ ⑥ ⑦

D. Foster
(Stanford Law)
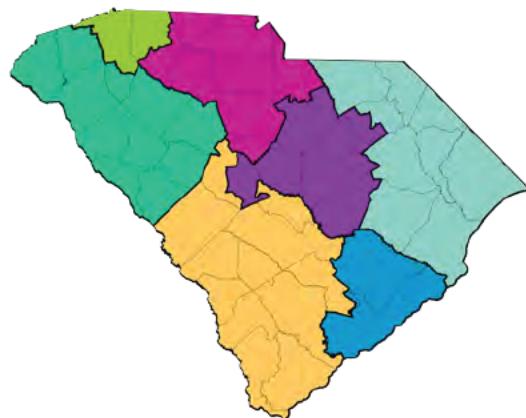
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(no affiliation given)
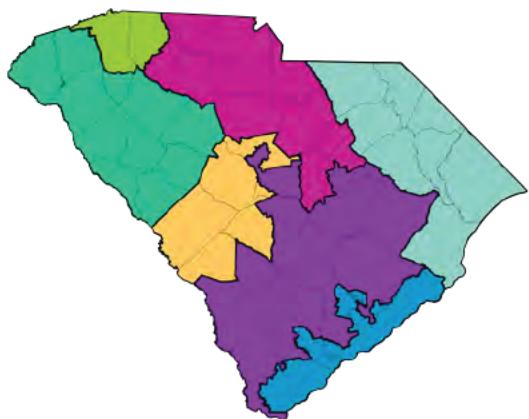
G. Muscatel
(Stanford Law)
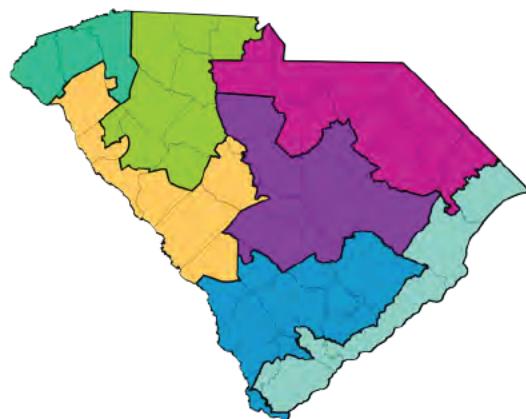
J. Sukovich
(Newberry County Democrats)

M.Roberts
(no affiliation given)

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2   Demographics in South Carolina

In South Carolina, the total population from the 2020 Decennial Census is 5,118,425. Of those, 1,370,542 are identified as Black on their Census forms—this makes up roughly 26.78% of the population. By focusing on those who answered "Yes" to the question of Black racial identity, we use what is sometimes called the *Any Part Black* definition of Black population—this means Black alone or in combination with any other racial or ethnic category. If the most restrictive definition of Black population were used instead, namely non-Hispanic respondents choosing Black and no other race, then the population number would drop to 1,269,031, or 24.79% of population. For the remainder of this report, "Black" refers to the larger definition.

When considering residents of voting age, the Black population is enumerated at 1,014,656 out of 4,014,460, or 25.28%. I will refer to this population share as BVAP, or Black voting age population. Passing to estimates of Black *citizen* voting age population (or BCVAP), the share shifts to 1,007,692 out of 3,877,913, or 25.99%.
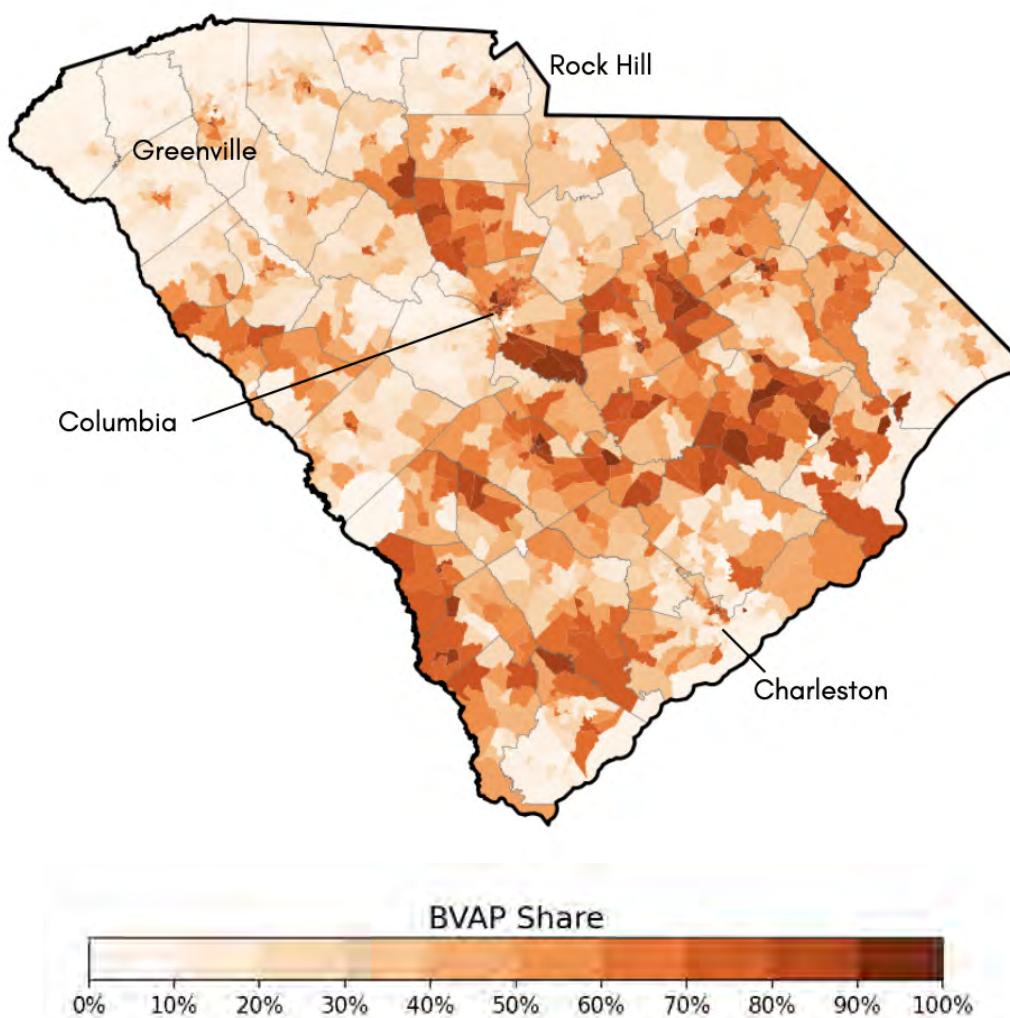
Figure 1: This choropleth map shows the share of Black voting age population shaded by VTD (i.e., by voting precinct) across South Carolina, overlaid with the boundaries of the 46 counties.

Change in BVAP
by county

Change in BVAP
by census tract

Number of People
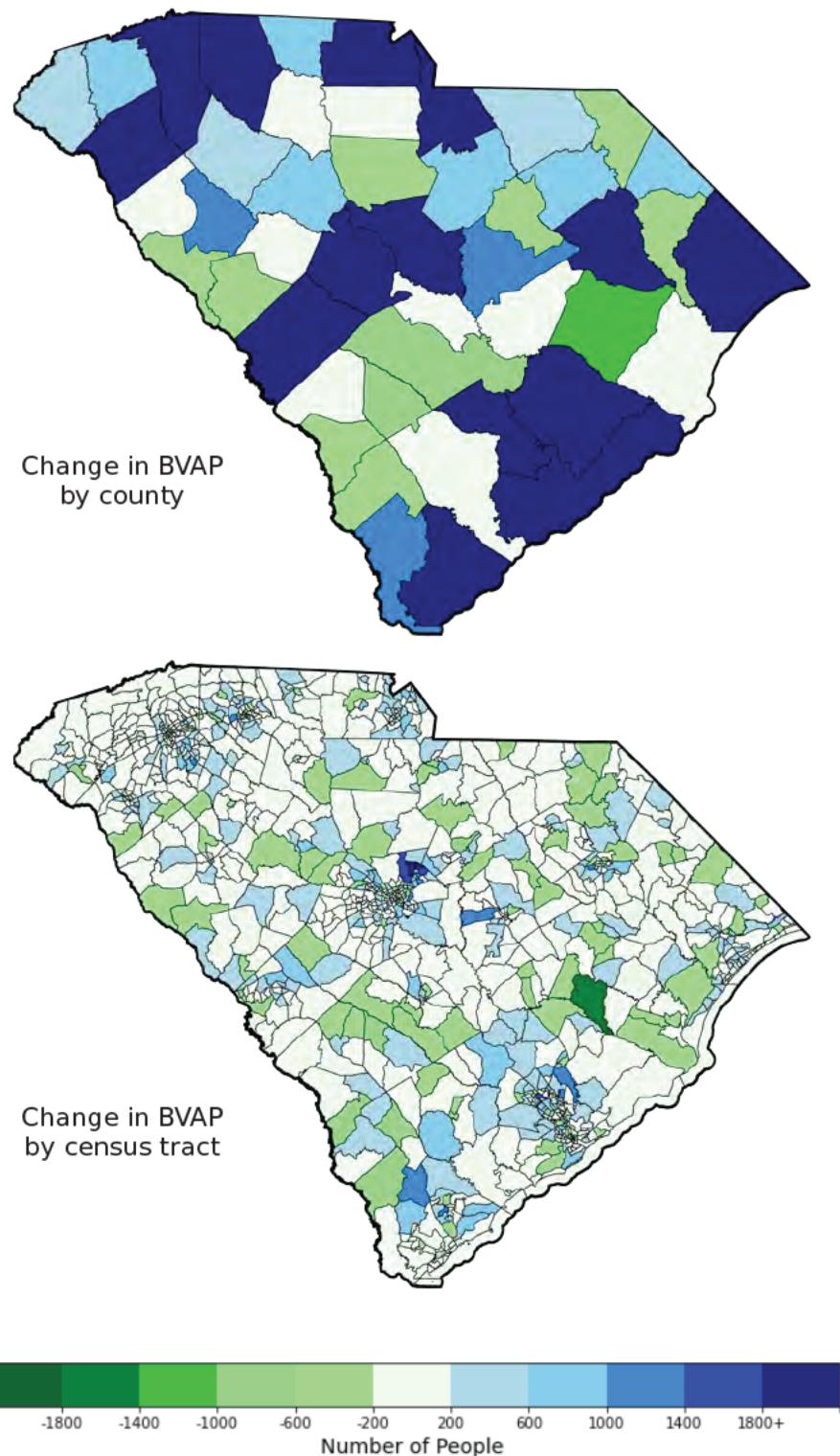
Figure 2: These maps show the shifts in Black population in South Carolina, according to American Community Survey estimates comparing 2010 and 2019. Black population has grown in the Columbia area and parts of greater Charleston, particularly, creating the demographic conditions for increased electoral influence.

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3 Redistricting criteria

The Guidelines issued by the House and Senate are substantially similar; I will focus below on the House Guidelines and make notes as to where the Senate Guidelines agree or differ.

3.1 First-tier requirements

Minority opportunity. The first specific districting criterion discussed in the House Guidelines is the safeguarding of minority opportunity to elect candidates of choice, referencing the Voting Rights Act of 1965 and more generally federal and state law. The House Guidelines affirm that "Any proposed redistricting plan that is demonstrated to have the intent or effect of dispersing or concentrating minority population in a manner that prevents minorities from electing their candidates of choice will neither be accepted nor approved."[2]

I note that both sets of Guidelines clearly contemplate the use of race data in ensuring compliance with the VRA: "race may be a factor considered in the creation of redistricting plans, but it shall not be the predominant factor motivating the legislature's decisions concerning the redistricting plan and shall not unconstitutionally predominate over other criteria set forth in these guidelines."[3]

Population balance. The standard interpretation of *One Person, One Vote* is that districts, especially Congressional districts, should be balanced to near mathematical equality of population, using total population from the Decennial Census.

For population balancing, the House Guidelines cite the Congressional ideal of 731,204 people per district derived from the PL94-171 and, by referencing "strict equality," imply that we should seek to have four districts at 731,204 and three at 731,203. The Senate Guidelines explicitly call for one-person top-to-bottom deviation for Congressional districts.

3.2 Second-tier requirements

The previous criteria (covered in I-IV of the House Guidelines) are rooted in the Constitution and in federal and state law. Next, the Guidelines delineate four traditional principles that should be considered in South Carolina redistricting, though their role is clearly meant to be subordinate to the requirements of I-IV, and therefore they may need to give way in case of conflict.[4]

Contiguity. A district is regarded as contiguous when it is one connected piece. More precisely, a district formed from census blocks is called contiguous by the standard definition if it is possible to transit from any part of the district to any other part through a sequence of blocks that share boundary segments of positive length from one to the next. In South Carolina, in accordance with the guidance in Section V of the House Guidelines, contiguity by water is acceptable; however, areas that only intersect at a single point or "points of adjoining corners" are not considered contiguous. Interestingly, point contiguity is allowed in the Senate Guidelines, as long as pairs of districts do not cross over each other at such a point.

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[2]The Senate Guidelines are nearly identical, noting that Congressional plans "must not have either the purpose or the effect of diluting minority voting strength".

[3]The Senate language is similar: "consideration of race is permissible," but any predominance of race-neutral considerations must be narrowly tailored.

[4]Similarly, the Senate Guidelines cover population balance and minority opportunity in Section I, then contiguity in Section II, putting communities of interest, district cores, the integrity of political subdivisions (counties, cities, towns, and VTDs), and compactness into Section III, entitled "Additional Considerations."

Compactness.   The criterion of district compactness is the principle that districts should be reasonably shaped, not eccentric or irregular. The House Guidelines note that districts that are not visually compact can sometimes be justified by the shape of census block boundaries or natural geography and by the creation of districts to comply with the VRA.[5]

The House Guidelines remark that compactness "should be judged in part by the configuration of prior plans... [but] should not be judged based upon any mathematical, statistical, or formula-based calculation or determination." Despite this expressed preference, metrics are routinely used in redistricting analysis and litigation, so I will report them here.

The two most common compactness metrics are the Polsby-Popper score and the Reock score. These are both *contour-based* scores that rely on the outline of the district on a map. *Polsby-Popper* is a ratio formed by comparing the district's area to its perimeter. *Reock* considers how much of the smallest bounding circle is filled out by the district's area. Recently, mathematicians have argued for the use of discrete compactness metrics that de-emphasize the outline and instead consider how the districts are formed from units of census geography. *Block cut edges* is a metric that counts the number of census blocks that are adjacent to each other in the state, but are assigned to different districts. This assesses the "scissors complexity" of a plan, giving a measure of how many blocks would have to be separated from one another to divide up all the districts. An advantage of the contour scores is that they are familiar and in wide use. An advantage of discrete scores is that they do not excessively penalize districts for having winding boundaries when those boundaries come from physical geography, like coastlines or rivers.

Communities of interest (COIs) and political boundaries.   Communities of interest are geographical areas where residents have shared interests relevant to their representational needs. The Senate Guidelines spell this out as "geographical, demographic, historic, or other characteristics that cause people to identify with one another, including economic, social, cultural, language, political, and recreational activity interests." (This is condensed but similar to the language in the House Guidelines.)

In numerous states, the legislature or other government offices launched an effort to collect COI testimony accompanied by digital mapping from members of the public, coordinated with the new Decennial Census data. I have reviewed the public testimony collected by the state and published online on the redistricting sites for the Senate and House [10, 7]. The oral testimony was not accompanied by mapping submissions, but I have made a serious effort to screen it comprehensively and take it into account in this report wherever possible.

Many submitted comments were broad or theoretical, such as the general importance of communities; preserving county and municipal boundaries; concerns about partisan and racial gerrymandering; competitiveness; transparency and public participation; and deprioritizing incumbency protections. But notably, speakers also named particular counties, regions, or metropolitan areas with specific representational concerns. For instance, commenters spoke to Dorchester County, the Lowcountry, North Charleston, Orangeburg, Columbia, and Sumter communities of interest, which will be discussed below in the detailed district review (§5).

In line with some of the public commenters, the House Guidelines fold what is usually a separate principle into the category of COIs. Namely, it is very common in redistricting to require respect for political boundaries, especially for the boundaries of counties, cities, and towns. In South Carolina, counties, municipalities, and precinct/VTD lines are explicitly classified as a part of the COI principle, "but will be given no greater weight, as a matter of state policy, than other identifiable communities of interest." The Senate Guidelines split out respect for counties (III.C), cities and towns (III.D), and VTDs/precincts (III.E) under separate headings.

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[5]Compactness is also sometimes used to describe population distributions rather than districts; in that usage, compact populations are those that are clustered rather than dispersed. Notably, the Senate Guidelines shy away from shape considerations entirely, referencing what is sometimes called *functional compactness*: "the extent to which points of the district are joined by roads, media outlets, or other means for constituents to communicate effectively with each other and with their representative."

4   Review of metrics for Congressional maps

This section reports metrics for all of the Congressional maps discussed in this report. These include measurements of traditional redistricting criteria such as compactness and geographic splits, as well as demographic data.

4.1   Racial demographics

The plans submitted to the legislature for consideration differ greatly in their distribution of Black population over the districts. The following tables present the BVAP by district for each of the plans, and then identify the number of districts surpassing thresholds of 50, 40, and 30% BVAP. Recall that, as described above, BVAP measurements in this report are with respect to so-called Any Part Black categories (i.e., Black alone or in combination).

	CD 1	CD 2	CD 3	CD 4	CD 5	CD 6	CD 7
Previous2012	0.173	0.239	0.174	0.183	0.257	0.525	0.254
Enacted2022	0.174	0.254	0.176	0.19	0.247	0.469	0.254
SC-NAACP1	0.349	0.205	0.16	0.172	0.244	0.528	0.117
SC-NAACP2	0.24	0.202	0.18	0.185	0.202	0.503	0.254
Harpootlian	0.212	0.219	0.156	0.162	0.337	0.497	0.184
LWVSC	0.233	0.197	0.169	0.191	0.244	0.488	0.245
Foster	0.244	0.208	0.143	0.153	0.202	0.323	0.496
Muscatel	0.167	0.248	0.178	0.184	0.247	0.488	0.254
Harrison	0.233	0.276	0.185	0.177	0.277	0.352	0.267
Sukovich	0.293	0.184	0.143	0.211	0.319	0.493	0.129
Roberts	0.233	0.315	0.197	0.386	0.321	0.167	0.151

	#districts with >50% BVAP	# districts with >40% BVAP	#districts with >30% BVAP
Previous2012	1	1	1
Enacted2022	0	1	1
SC-NAACP1	1	1	2
SC-NAACP2	1	1	1
Harpootlian	0	1	2
LWVSC	0	1	1
Foster	0	1	2
Muscatel	0	1	1
Harrison	0	0	1
Sukovich	0	1	2
Roberts	0	0	3

Table 1: The first table gives Black voting age population share by district for the plans under consideration. The second table shows the number of districts that have BVAP over 50%, 40%, and 30%, respectively.

4.2 Population deviation

One Person, One Vote calls for plans to have nearly equal population across their districts. Over the ten years between Decennial Census releases, districts grow quite malapportioned due to natural population shifts between and within the states. In South Carolina, the deviation grew to over 170,000 from top to bottom.

All of the new plans reduce the deviation significantly, with Enacted2022, SC-NAACP1, SC-NAACP2, Harpootlian, LWVSC, Foster, and Muscatel all achieving top-to-bottom deviation in the single digits.

	Maximum positive deviation	Maximum negative deviation	Top-to-bottom deviation
Previous2012	87,689	−84,741	172,430
Enacted2022	0	−1	1
SC-NAACP1	1	−1	2
SC-NAACP2	1	−3	4
Harpootlian	1	−3	4
LWVSC	3	−2	5
Foster	0	−1	1
Muscatel	0	−1	1
Harrison	630	−668	1298
Sukovich	746	−944	1690
Roberts	1790	−724	2514

Table 2: Population deviation in each plan.

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4.3 Compactness

In terms of district shape, the state's enacted plan, like the state's plan from the previous cycle, is only moderately compact compared to some of the other proposals submitted to the legislature. For example, LWVSC and SC-NAACP2 plans are more compact than both state maps—Previous2012 and Enacted2022—by all three featured metrics of compactness. The Harpootlian plan beats the state's maps on the Polsby-Popper and cut edges scores, though not on the Reock score.

	avg Polsby-Popper (higher is better)	avg Reock (higher is better)	Block cut edges (lower is better)
Previous2012	0.202	0.369	3217
Enacted2022	0.210	0.361	2843
Harpootlian	0.235	0.327	2227
LWVSC	0.224	0.379	2392
SC-NAACP1	0.165	0.270	3578
SC-NAACP2	0.240	0.371	2343
Foster	0.273	0.376	2313
Muscatel	0.216	0.371	2955
Harrison	0.289	0.443	2074
Sukovich	0.208	0.324	2636
Roberts	0.177	0.308	3091
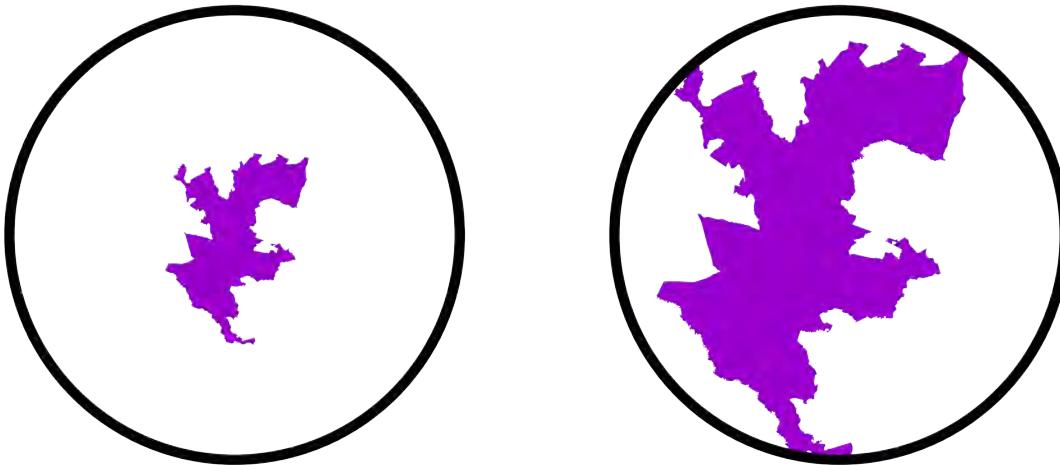
Table 3: Comparing compactness scores via one discrete and two contour-based metrics. The Polsby-Popper score compares a district's area to the area of the circle with the same perimeter (left). The Reock score compares a district's area to the area of the smallest circle that contains the district (right). These are illustrated using CD 6 from the state's plan Enacted2022, which has an extremely low Polsby-Popper score of 0.0754 (left) and a more moderate Reock score of 0.3569 (right).

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4.4 Political subdivisions

Respect for the integrity of political subdivisions—units such as counties and cities—is a traditional principle in its own right. In South Carolina, it is also named as a communities of interest consideration in the legislative Guidelines.

In the tables below, each "splits" score counts the number of units that are assigned to multiple districts, while each "pieces" score adds up, over the divided units, how many districts they touch. For example, if one county is split two ways and another is split three ways, this would count as a total of two split counties and five county pieces.

In Table 4, we see the splits/pieces counts for counties and county subdivisions. County subdivisions are a census data product; subdivisions nest inside counties and respect municipalities, tending to have more regular boundary lines than municipalities themselves.

	County Splits (out of 46)	County Pieces	Subdivision Splits (out of 271)	Subdivision Pieces
Previous2012	12	24	39	78
Enacted2022	10	20	29	58
SC-NAACP1	19	39	49	99
SC-NAACP2	14	30	30	61
Harpootlian	7	14	12	24
LWVSC	6	12	24	48
Foster	9	19	26	53
Muscatel	12	24	31	62
Harrison	6	12	15	30
Sukovich	13	26	23	46
Roberts	7	15	22	46

Table 4: This table presents the number of county and county subdivision splits and pieces in each plan.

In the cities and towns analysis, I will distinguish the splits and pieces that merely impact the *territory* from the splits that actually divide *population*. Note that the population splits are often smaller, because boundaries of cities can be quite complicated and sometimes only an unpopulated outlying area is divided from the rest of the city—this would count as a territory split, but not as a population split. Table 5 shows the counts.

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	City Splits (out of 69)	City Pieces	Town Splits (out of 202)	Town Pieces
Previous2012	13 / 13	26 / 26	6 / 5	12 / 10
Enacted2022	10 / 10	20 / 20	12 / 10	24 / 20
SC-NAACP1	15 / 13	30 / 26	11 / 10	22 / 20
SC-NAACP2	9 / 7	18 / 14	13 / 10	27 / 21
Harpootlian	9 / 7	18 / 14	7 / 6	14 / 12
LWVSC	6 / 5	12 / 10	5 / 4	10 / 8
Foster	11/ 10	22 / 20	8 / 5	16 / 10
Muscatel	16 / 16	32 / 32	7 / 6	14 / 12
Harrison	11 / 11	22 / 22	6 / 6	13 / 12
Sukovich	14 / 13	28 / 26	8 / 7	16 / 14
Roberts	14 / 11	30 / 24	8 / 8	16 / 16

Table 5: This table presents city and town splits for each plan, with both territory splits and population splits shown. For example, the Harpootlian plan city splits are shown as 9 / 7, meaning that the plan splits the territory of nine cities across multiple districts, but only seven of those splits involve populated blocks.

4.5 Incumbency

The plans under consideration vary in their treatment of incumbents, from zero to three pairings.

- Previous2012: none
- Enacted2022: none
- SC-NAACP1: none
- SC-NAACP2: none
- Harpootlian: none
- LWVSC: one pair
    - CD 3: Duncan (R) / Timmons (R)
- Foster: one pair
    - CD 4: Rice (R) / Mace (R)

- Muscatel: none
- Harrison: one pair
    - CD 6: Clyburn (D) / Wilson (R)
- Sukovich: one pair
    - CD 4: Rice (R) / Norman (R)
- Roberts: three pairs
    - CD 2: Wilson (R) / Mace (R)
    - CD 3: Rice (R) / Norman (R)
    - CD 5: Duncan (R) / Clyburn (D)

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5   Detailed district review

The complaint filed by the SC-NAACP cites Congressional districts 1, 2, and 5 from the newly-proposed plan Enacted2022 as having being drawn to dilute Black voting power. Since these districts surround district 6—the only district in the state's plan that presents electoral opportunity to Black voters—we will discuss CD 1, CD 2, and CD 5 in relation to CD 6.

First, we recall the levels of Black voting age population and the compactness scores for each district. Note: only Polsby-Popper is cited here because it is by far the most commonly used compactness score. Cut edges, in particular, is only defined for whole plans and not for individual districts.

Enacted2022	1	2	5	6
BVAP	.174	.254	.247	.469
Polsby-Popper	.146	.171	.229	.077

Enacted2022

BVAP Share

14
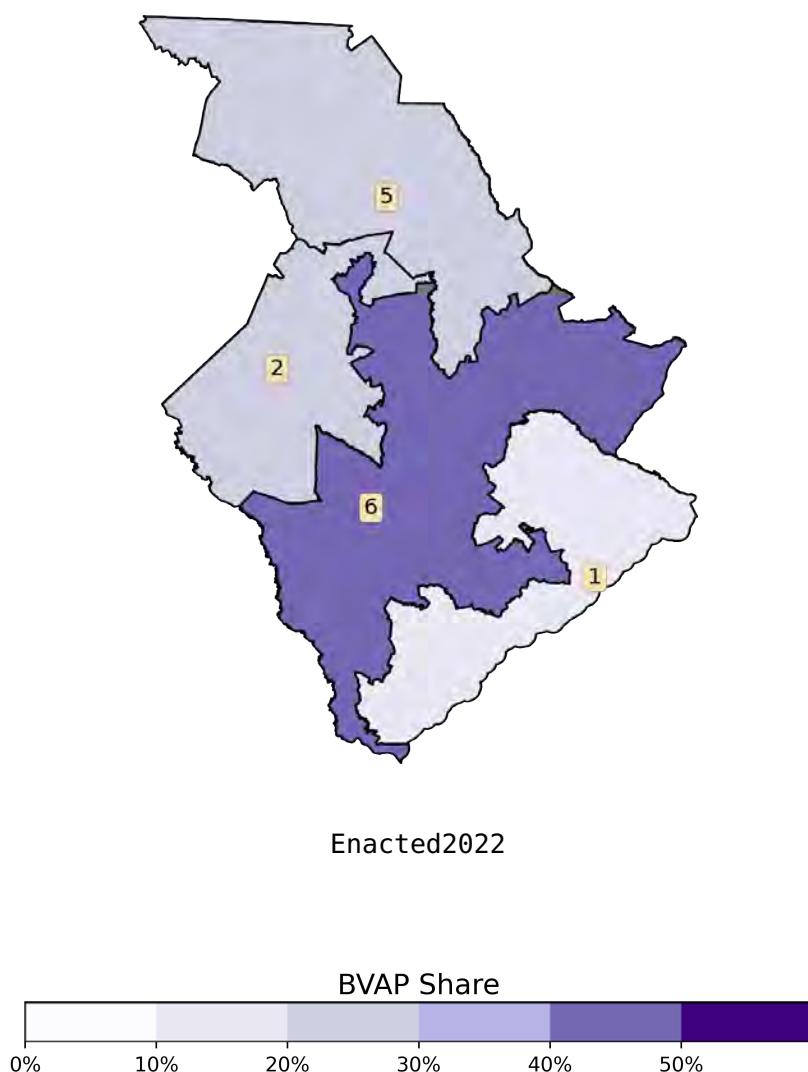
In the reconfiguration between `Previous2012` and `Enacted2022`, the movement of terrain between key districts is shown below in Figure 3
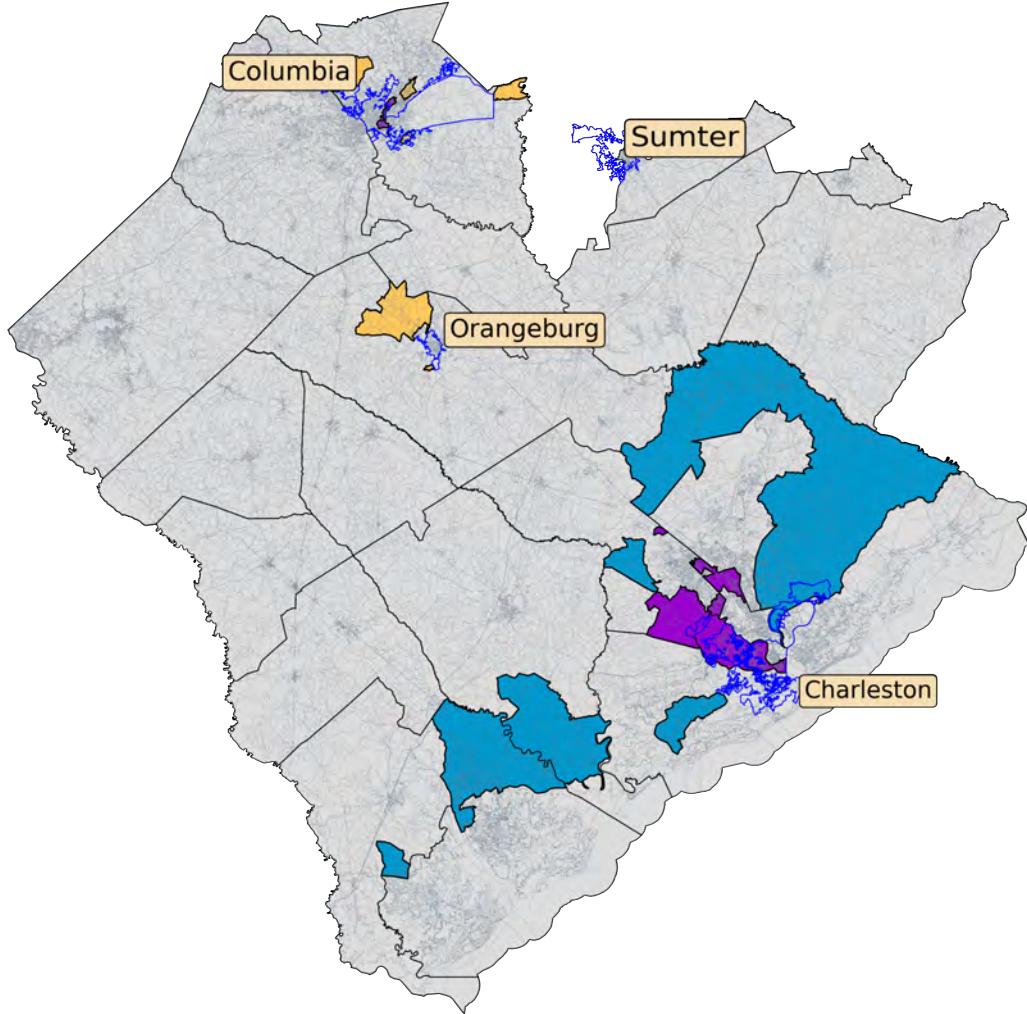

Figure 3: Terrain moved in and out of CD 6. Areas are colored in terms of their district reassignment. Yellow areas were moved from CD 6 to CD 2; blue was moved from CD 6 to CD 1, and purple areas were moved into CD 6 from the neighboring districts.

As the figure makes clear, the reassignment is happening in scattered chunks and shards, and is not aimed at healing key splits of cities and communities that were frequently cited in the public testimony, including Columbia, Sumter, Orangeburg, and Charleston. This produces a map that cuts those areas in a way that neither respects traditional redistricting principles nor publicly identified community needs, as I will detail in the remainder of this section.

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5.1 CD 1
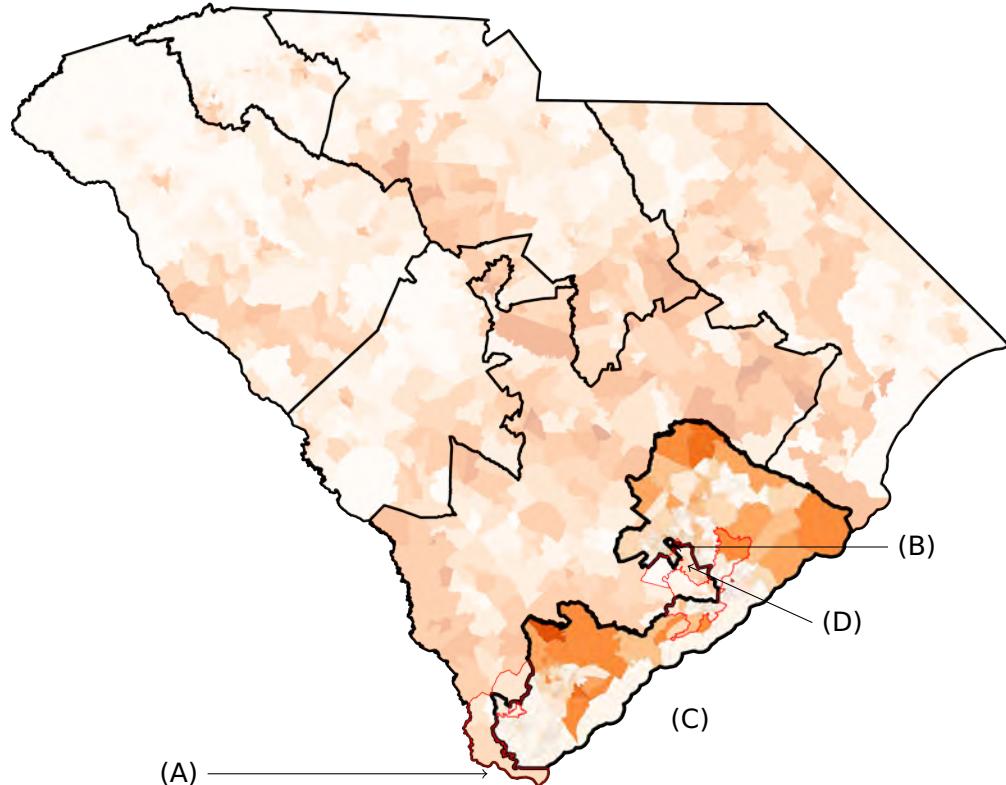
Figure 4: CD 1 is highlighted, with the Black voting age population as in Figure 1 and split cities outlined in red.

    The first Congressional district in the Enacted2022 map comprises all of Berkeley and Beaufort Counties and pieces of Jasper, Colleton, Charleston, and Dorchester Counties. Within Charleston County, the CD 1 and CD 6 boundary follows natural geography, but only until reaching Berkeley County.

(A) **Jasper County split.** Jasper County, which was previously intact in the enacted 2012 map, is split. Only two of its precincts are included in the new CD 1.

(B) **Dorchester County split illogically.** The district makes an unnecessary detour from Berkeley County into Dorchester County, involving six precinct splits that do not follow any major roadways or bodies of water. The reasons for splitting precincts are not clear, but they result in two separate pieces of Dorchester County being found in CD 6. The split precinct pieces show a noticeable racial skew—five out of six split precincts have a significant BVAP differential between the piece in CD 1 and the piece in CD 6, with higher Black population share on the CD 6 side, consistent with a strategy of cracking in CD 1.

(C) **Coastal and Lowcountry COIs disregarded.** COI testimony asks to keep together the coastal communities and "Lowcountry" counties—principally Jasper, Charleston, Colleton, and Beaufort—but these are split in the state's map. By contrast, the Harpootlian proposal is highly cognizant of these COIs.
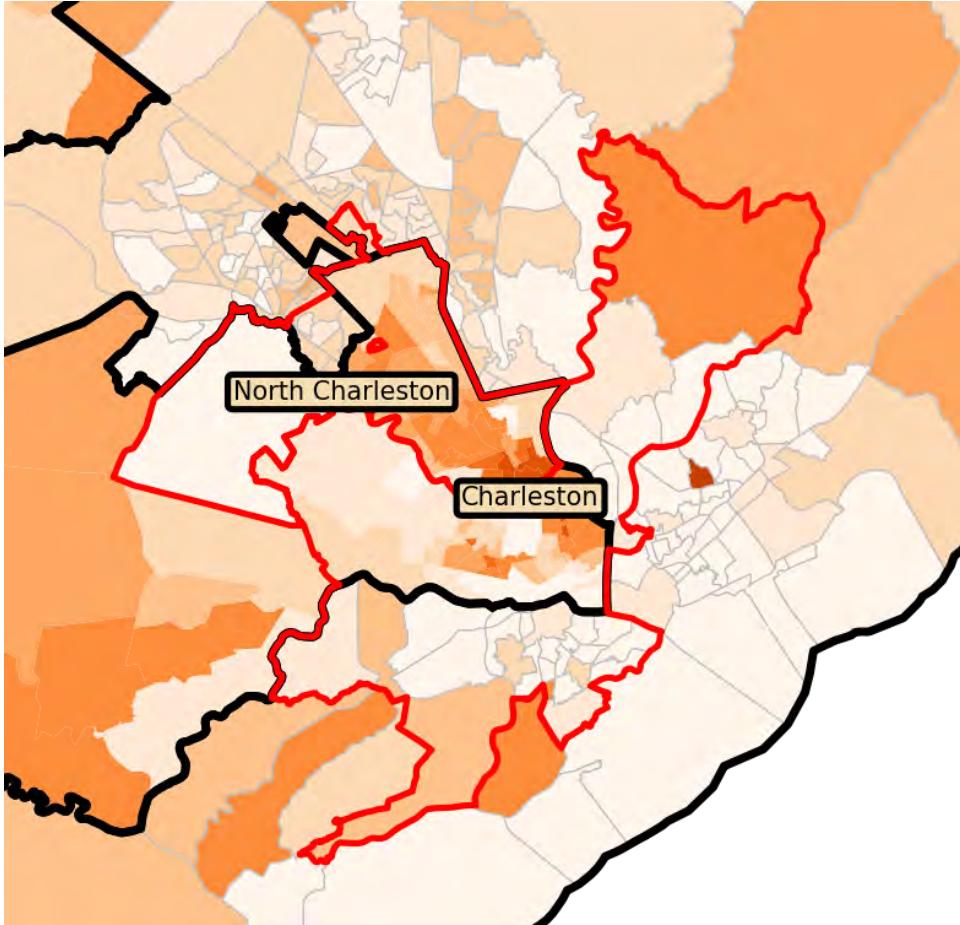
Figure 5: North Charleston is split between CD 1 and CD 6 as the district line winds between counties, in and out of the city, and through neighborhoods with significant Black population.

(D) **Charleston County split erratically.** Charleston County boundaries appear to be selectively followed, ignoring communities cited in public testimony, which notably highlights "Charleston and surrounding towns." The cities of Summerville and Ladson are part of both Berkeley and Dorchester Counties, while North Charleston spans these two counties as well as Charleston County. The state has split all three cities: for Summerville and Ladson, the district boundary follows the county line, but for North Charleston the district winds around to grab a small piece of the city. (See Figure 5) All of these important communities could have been kept whole. Public comment is particularly vocal on North Charleston, saying that the city has more in common with Charleston than with Columbia, and more in common with the Lowlands than the Midlands.

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5.2 CD 2
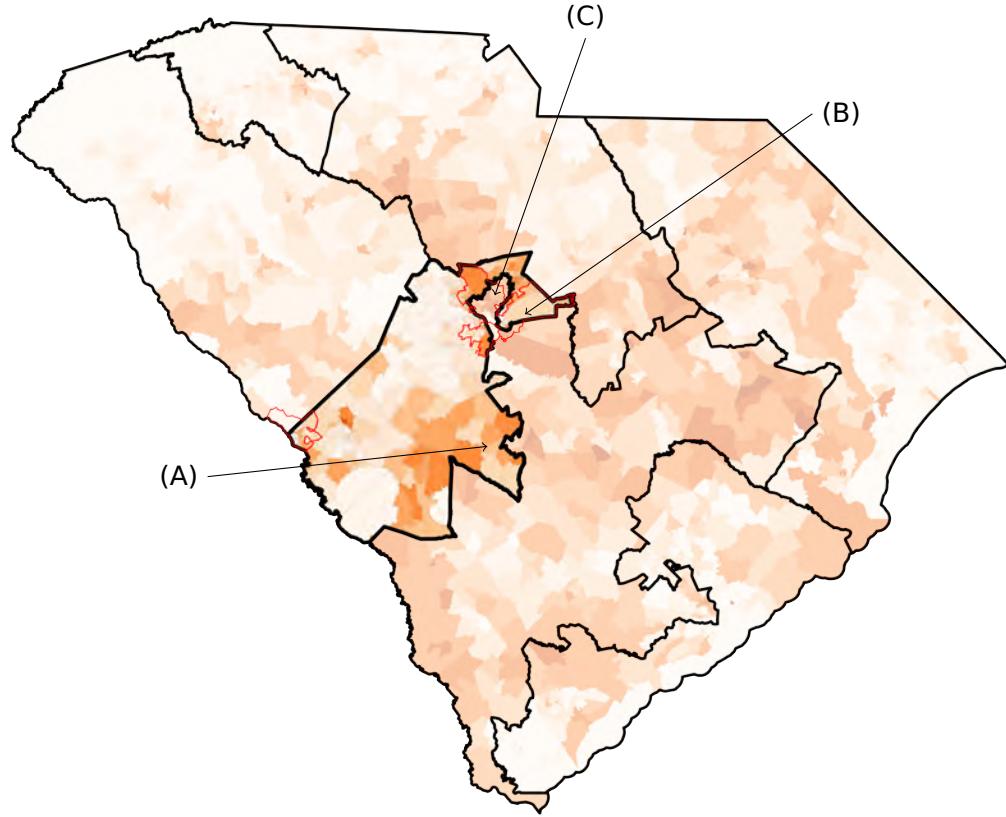
Figure 6: CD 2 is highlighted, with the Black voting age population as in Figure 1 and split cities outlined in red.

The second district is made up of the entirety of Aiken, Barnwell, and Lexington Counties and pieces of Orangeburg and Richland Counties.

(A) **Orangeburg separated from CD 2.** The CD 2 boundary forms a ring around the western Orangeburg suburbs, keeping the city of Orangeburg in CD 6. The public comment indicates, by contrast, that Orangeburg has more in common with the adjoining areas of CD 2.

(B) **Hook into Columbia.** In Richland County, CD 2 wraps circuitously around the greater Columbia area in a non-compact hook shape in the prior plan `Previous2012`—and though the details are different, that hook shape is preserved in the new plan `Enacted2022`. It appears to crack voters by drawing district boundaries through an area in northern Richland with high BVAP. (See Figure 7.)

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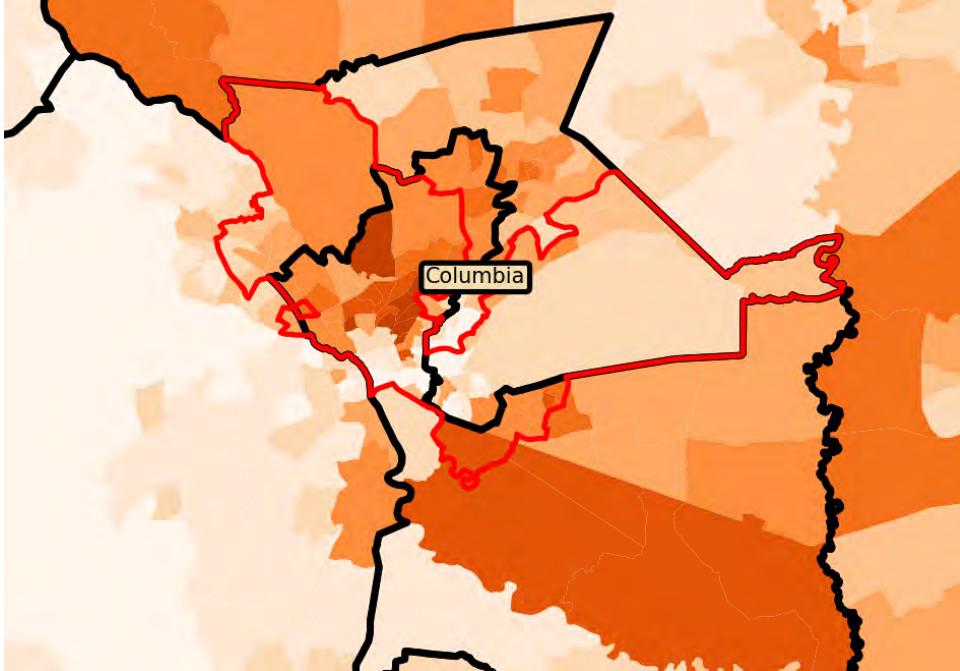
Figure 7: District lines wrap around and divide the city of Columbia. This splits both the city and the county in a manner that cracks Black population.

(C) **Splitting in and around Columbia.** In Richland County, the cities of Cayce, Columbia, and Forest Acres are all split, along with two precincts that are split in a manner that does not appear to follow major roads. If the district line traced along the Richland County boundary, or at least divided the county in a less winding manner, it would avoid needless splitting and confusion. Some public comment suggests that the Columbia area contains communities that are linked, but that these linked communities were divided by the CD 6 "bulb" in Columbia. As William Maxie testified: "Do people in downtown Columbia not have that much in common with people from Forest Acres or people right across the [Congaree] river? No, they do. That's where a lot of people live and a lot of those people work." (Appendix B)

5.3 CD 5
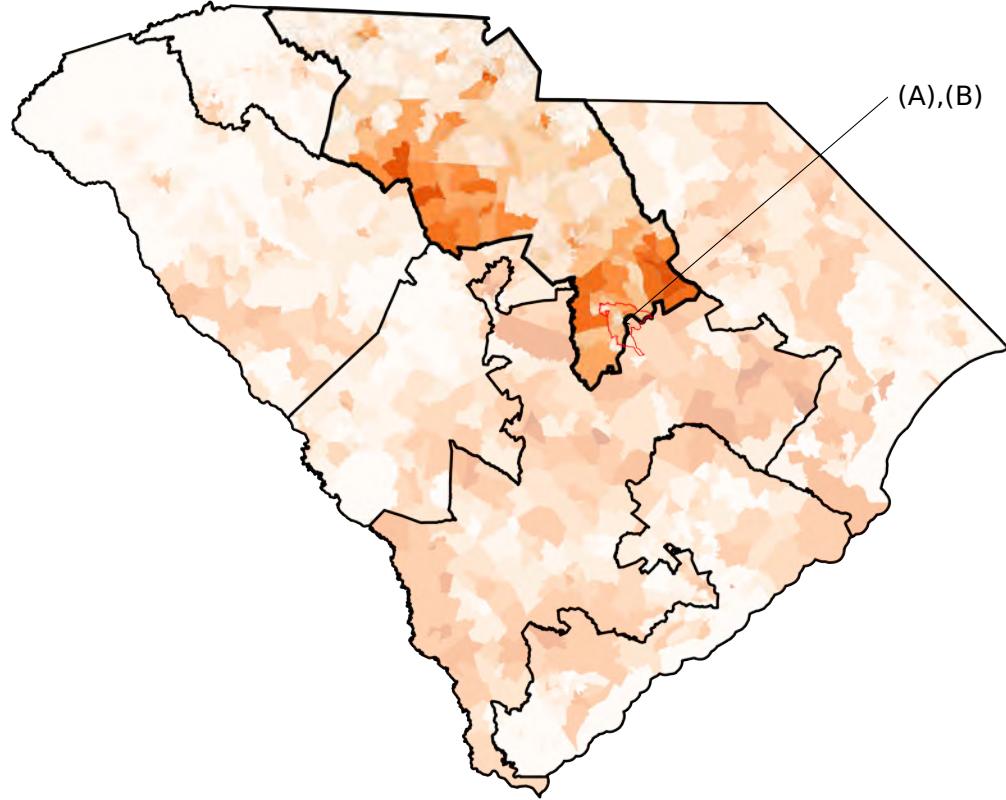
Figure 8: CD 5 is highlighted, with the Black voting age population shown as in Figure 1 and the split city of Sumter (pop. 43,463) outlined in red.

The fifth district covers all of Cherokee, York, Union, Chester, Lancaster, Fairfield, Kershaw, and Lee Counties and pieces of Spartanburg County along the CD 5 and CD 4 boundary and Sumter County along the CD 5 and CD 6 boundary.

(A) **Sumter COI not respected.** The city of Sumter and the neighborhoods of East Sumter and Mulberry are three majority-Black communities split by the enacted map.[6] The public testimony suggests that the city of Sumter and Sumter County are each important communities—these are referenced by at least four commenters. For instance, Archie Parnell testified that "I think there is a community of interest here in Sumter and I would urge you to continue with your criteria that you've adopted 10 years ago and, hopefully, keep counties together."

(B) **Sumter split is illogical.** In Sumter County, one precinct is split along several low-density residential roads (W Oakland Ave, Cemetery Road, Carver Street, Green Swamp Road, Bradford Street, and Council Street). This portion of W Oakland Ave and all of Cemetery Road appear to be in the middle of a cemetery.

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[6]Sumter in particular is roughly 51% Black by population.
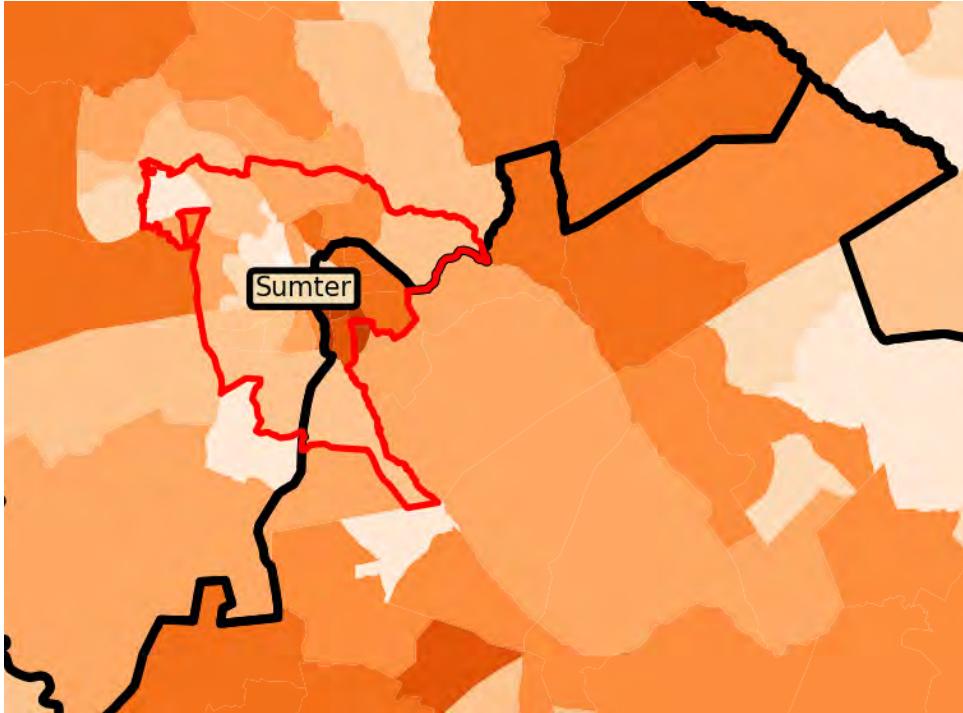
Figure 9: Sumter, a small majority-Black city cited in public testimony as an important community, is split in the state's map as the CD 5/CD 6 dividing line wends through a heavily Black region.

See Appendix B for a large selection of public testimony supporting the points raised in this section.

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6 Vote dilution compared to the neutral baseline

In order to illustrate the universe of possibilities when some or all districts are redrawn, I have used a method that is increasingly popular in the peer-reviewed scientific literature as well as courts of law.[7] This is called the *ensemble method* for redistricting, where randomized algorithms are used to construct large numbers of sample plans that vary district lines while holding the rules and geography constant. This is a popular method for determining whether some property of districting plans is an inevitable consequence of the rules and geography, or whether neutrally drawn alternatives show evidence that the unusual property is intentional. In this section, I will investigate evidence of whether the state's plan has *cracked* the Black population across districts 1, 2, 5, and 7, which show sharply less Black population than the level in CD 6. To do this I will focus on the demographic statistics of *the district with second-highest BVAP* in the state's plans, compared to alternatives.

I have used the Python package `GerryChain`, developed in my Lab and openly available to the public since 2018, to generate several ensembles of 100,000 alternative plans each. Population balance and contiguity are enforced throughout the algorithm, and it is implemented with a preference for compactness and for the preservation of counties and municipalities. I performed runs which attempt to prioritize the preservation of certain communities of interest identified in public testimony, and also runs that did not operationalize the COI concept. (For details, see Supplement A.) Ensemble generation made no use of race data and are *neutral* with respect to all other properties except those listed here.

6.1 Statewide

Using neutral ensembles of districting maps, we can compare the properties of a plan to alternative statewide plans that were made under traditional criteria. A histogram showing the distribution of Black population in the *second-highest district* is given in Figure 10 Cracking would tend to show up as unusually low BVAP in the second-highest district. This is exactly what we observe in Figure 10

Comparing to the neutral ensemble—which was constructed with the same natural and physical geography that faced the legislature, and with the traditional districting principles enforced—illustrates that the cracking that was qualitatively described in the last section does indeed amount to dilution of Black population with respect to a neutral baseline. And we note that the contrast with the `SC-NAACP1` and `Harpootlian` maps, which draw CD 6 with higher BVAP than `Enacted2022` (see Table 1), makes it clear that the BVAP dropoff is not merely a function of maintaining CD 6 at near-majority levels.

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[7]In this cycle, ensemble evidence has been accepted by courts in North Carolina, Pennsylvania, and Ohio. In the previous cycle, it formed a key component of the evidence in North Carolina and Pennsylvania that resulted in the invalidation of enacted plans in each state. Peer-reviewed publications include [2] [3] [1] and many more.
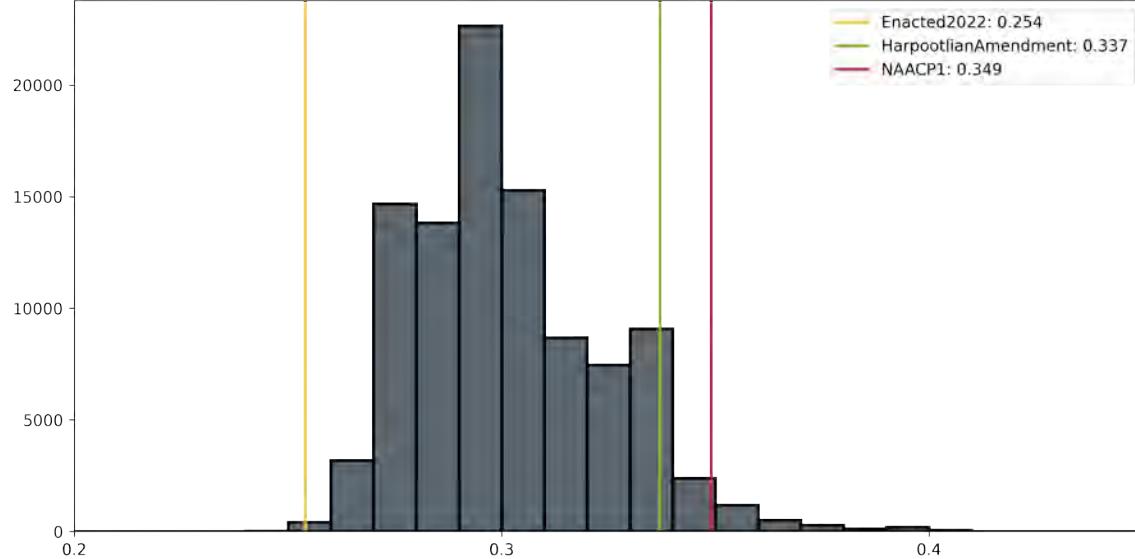
Figure 10: This histogram compares the district with *second-highest* BVAP in three current plans to those from 100,000 alternative plans. Most neutral plans are at or near 30% BVAP in their second highest district, while the state's plan is especially low. The SC-NAACP1 and Harpootlian plans are not cracked compared to the ensemble, even though they maintain CD 6 with BVAP levels above those in the state's plan.

6.2 Focused area

The complaint filed by the SC-NAACP specifically seeks relief for the dilution of Black voters in CD 1, CD 2, and CD 5. These districts cannot be adequately analyzed without the inclusion of CD 6 to the cluster. In order to show how these districts can be re-drawn, I have generated a new ensemble of 100,000 maps that only scrambles these four, preserving the state's CD 2, CD 3, and CD 7 exactly as drawn. In addition, I have identified an example of an alternative map (shown in Figure 11) that maintains CD 6 in nearly its exact configuration while un-cracking CD 5. Importantly, the alternative plan does not create an additional majority-Black district; rather, its CD 5 has just over 30% BVAP—a strengthened additional district, like CD 1 in the SC-NAACP1 alternative plan.[8]

Thus, whether we use a whole-state redraw or a targeted redraw, we find the state's plan to crack the Black population of South Carolina. As this section makes clear, many other possibilities were available to the state.

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[8]In the following section, I will explain a metric of the "effectiveness" of a district for Black voters, using four probative elections provided by counsel. In this alternative map, CD 5 does not always have a win for the Black candidate of choice—but that candidate receives at least 47.5% of the vote in each of the four elections, winning outright in one of the four. That performance corroborates the claim that this is a strengthened district for Black voters, and one in which a candidate would likely have to campaign in a way that led to some Black support in order to prevail.

Enacted districts   Alternative districts
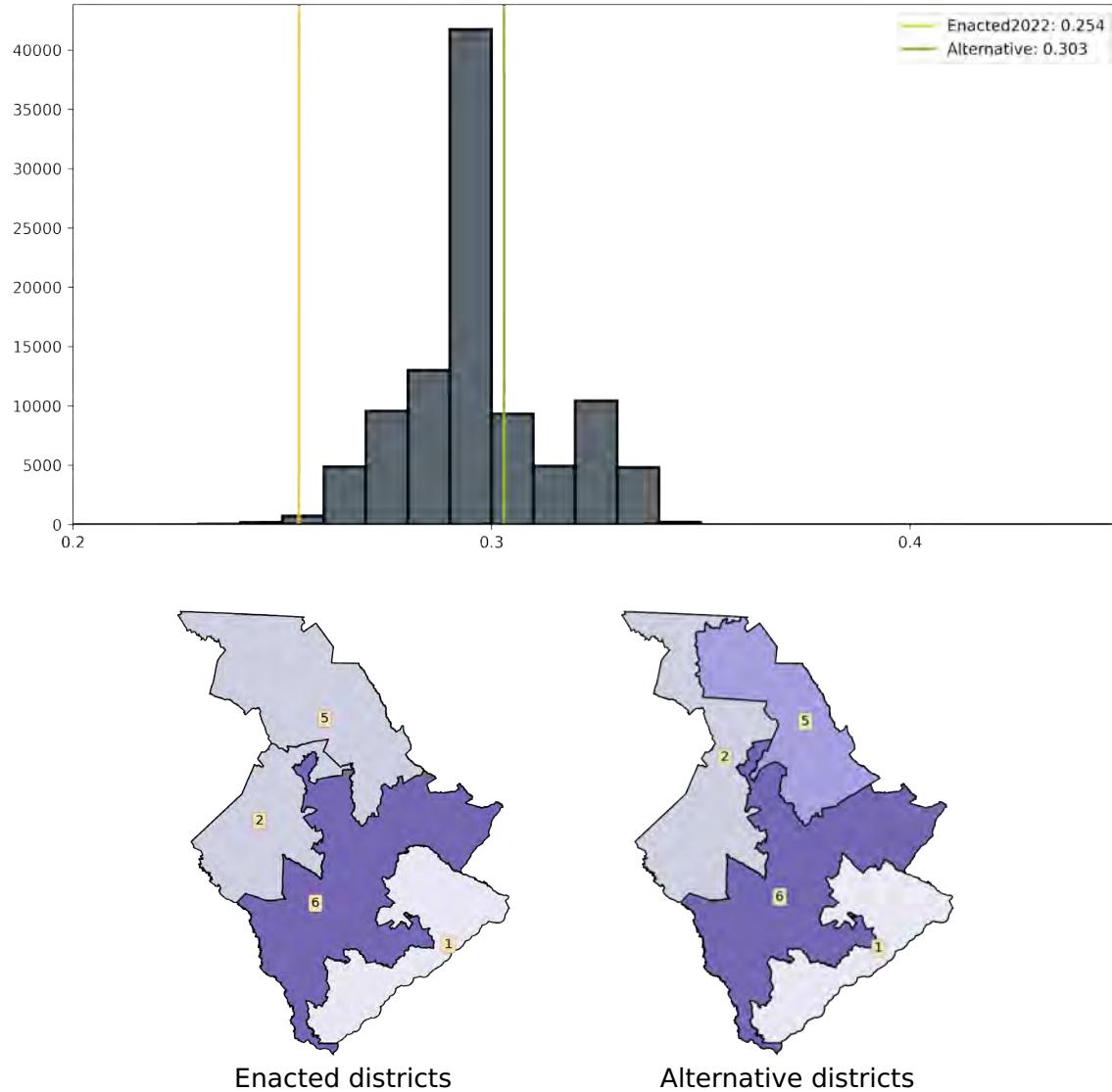
Figure 11: Histogram of BVAP in the second-highest district, comparing the low BVAP observed in the proposed plan to an ensemble of 100,000 sample plans that redraw only districts 1, 2, 5, and 6. An alternative plan is also shown—it leaves CD 6 and therefore CD 1 nearly unchanged, and unpacks this focus area mostly by changing a single (CD 2 / CD 5) boundary line.

7   Electoral opportunity for Black voters

Minority electoral opportunity is ultimately best gauged not by racial proportions in the population, but by an electoral history that shows that candidates of choice can be both nominated and elected. To measure that, we have used four recent statewide elections that were identified by counsel as particularly probative for Black electoral opportunity. These are the Secretary of State and Treasurer elections from 2018 and the U.S. Senator and President elections from 2020. In each case, a Black-identified candidate was on the ballot (including Kamala Harris on the Biden ticket). These elections have also been confirmed by counsel to display racially polarized voting, in which Black voters cohesively support the candidate of choice, while White voters form enough of a bloc to defeat these candidates in each election.

   If the Black candidate of choice won in each of the 4 elections in a district, we can label the district as highly *effective* from the point of view of Black electoral opportunity. The overall effectiveness of a 7-district plan is the sum of these 0-4 scores over each district, giving an overall score on a scale of 0-28.

	Black candidates of choice
Secretary of State 2018	Melvin Whittenburg
Treasurer 2018	Rosalyn Glenn
U.S. Senator 2020	Jaime Harrison
President 2020	Joe Biden / Kamala Harris

Table 6: Black candidates of choice were identified in a racially polarized voting analysis provided by counsel.

	Effectiveness (out of 28)	By District						
		1	2	3	4	5	6	7
Previous2012	4	-	-	-	-	-	4	-
Enacted2022	4	-	-	-	-	-	4	-
Harpootlian	6	2	-	-	-	-	4	-
LWVSC	6	2	-	-	-	-	4	-
SC-NAACP1	8	4	-	-	-	-	4	-
SC-NAACP2	8	4	-	-	-	-	4	-
Foster	10	4	-	-	-	-	2	4
Muscatel	4	-	-	-	-	-	4	-
Harrison	6	2	-	-	-	-	4	-
Sukovich	8	4	-	-	-	-	4	-
Roberts	11	2	3	-	4	2	-	-

Table 7: Effectiveness score across each proposed congressional plan in the four elections identified as probative for Black electoral opportunity. The state's plans from 2012 and 2022 confine Black electoral opportunity to a single district, where all four Black candidates of choice would have won the district, while none of them would have won in the other six districts. Only one other map under consideration (Muscatel) limits Black opportunities as starkly. Other plans extend effectiveness to more districts. SC-NAACP1 and SC-NAACP2 are reliably effective in both CD 1 and CD 6, while Harpootlian, for instance, would keep CD 1 within reach.

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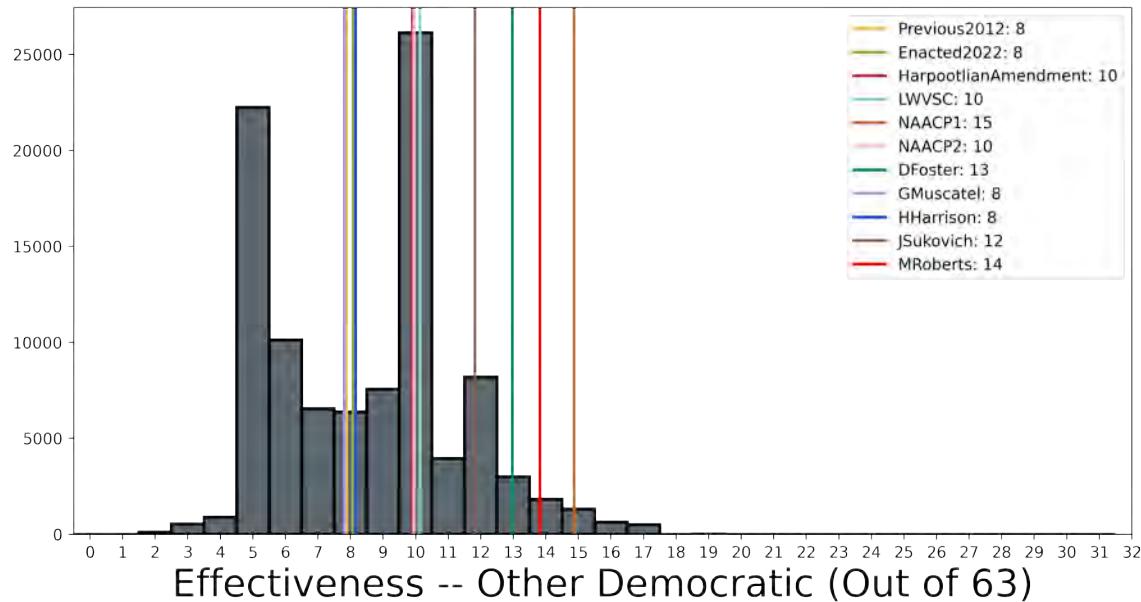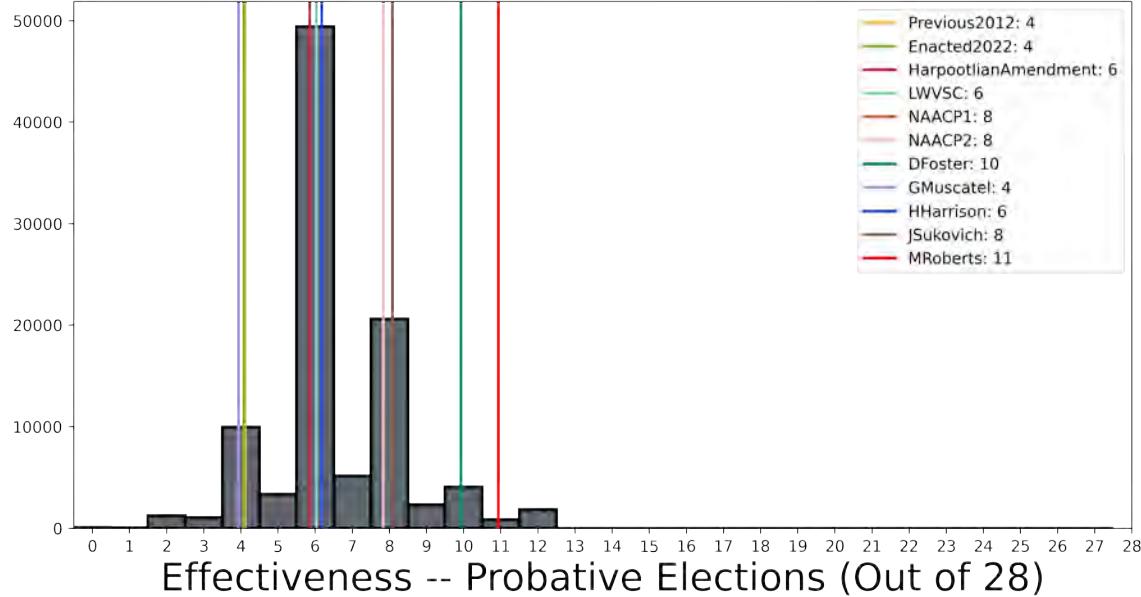
Figure 12: The comparison to 100,000 neutral plans shows that maps with such low levels of opportunity for Black voters are rarely found by chance (top), while the generic Democratic performance is much more typical (bottom). In particular, Previous2012 and Enacted2022 are both in the 12.4th percentile of effectiveness when it comes to the four probative elections for Black voters, but are right near the middle of the distribution (46.9th percentile) in the other seven contests evaluated here.

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We can make use of the neutral ensembles presented earlier to consider whether it is possible that such concentration of Black opportunity is merely a function of political geography. We find that it is not. Only 12.4% of maps drawn in a race-neutral fashion (top of Figure 12) have as low an effectiveness score as the state's plan when considering the probative elections. By far the most common outcome for these blindly drawn maps is 6 wins for the Black candidate of choice, with another significant spike at 8. This shows that many alternatives that were available to the legislature—from the SC-NAACP options to the LWV map to the compromise plan represented by the Harpootlian amendment—will tend to allow Black voters an opportunity to elect candidates of choice at a level in keeping with the human and political geography of the state. The state's maps from ten years ago and again from this year are the ones that are demonstrably dilutive, and as we've seen, they submerge traditional principles in order to secure this outcome.

This finding is even much strengthened by considering the wider dataset of all recent statewide general elections (bottom of Figure 12). This time, seven more general elections are evaluated: Attorney General 2018, Governor 2014, Governor 2018, Lt. Governor 2014, President 2016, Secretary of State 2014, Superintendent of Education 2014, U.S. Senator 2014, and U.S. Senator 2016. If we compare the four that are considered probative for Black electoral opportunity against the nine that are not designated in this way, the picture becomes extremely clear.

The state's plans `Previous2012` and `Enacted2022` are not outliers in their performance in generic partisan races, where they sit very near the middle of the pack; rather, they only stand out in the races with a Black candidate on the ballot, where the preferences of Black voters most diverge from those of White voters. Thus, it is not plausible that the concentration of Black voters in the state's plan was merely a side effect of partisan concerns. The state's plan is quite ordinary (46.9th percentile) in its effectiveness for the generic Democratic voter, but only shows up as unusually ineffective (dropping to the 12.4th percentile) when the races most probative for Black voters are separately considered.

8 Conclusion

By comparing various plans for South Carolina Congressional districting, I find that the state's plan `Enacted2022` expressly contravenes the legislature's own Guidelines, which clearly state that "Any proposed redistricting plan that is demonstrated to have the intent or effect of dispersing or concentrating minority population in a manner that prevents minorities from electing their candidates of choice will neither be accepted nor approved." Considering this strong guidance, and the increased Black population in the Columbia and Charleston areas (see Figure 2), we would expect increased electoral opportunities for Black voters to be reflected in the Congressional plan. By each kind of analysis provided above, we see that this is not the case; instead, Black population is cracked across Congressional districts 1, 2, and 5 in a way that demonstrably diminishes Black voters' ability to elect candidates of choice.

The state's plan draws its boundaries with a series of steps that (a) sacrifice traditional districting principles, and (b) harm Black voters by clear dilution of their voting power. These are shown in Section 4-5 and Sections 6-7 respectively. And I do not find these harms to be incidental. Each time I examined a decision with both racial and partisan elements in the design of the state's plan, I found that racial factors predominated over not only traditional principles, but even over partisan ones.

In this report, I have identified indicators of dilution of the Black vote both by showing the comparison to neutral plans and, crucially, by comparison to other plans that were available to the legislature at the time of plan adoption. The alternative provided in the Harpootlian Amendment, particularly, is far more respectful of communities of interest and goes a long way to remediate the vote dilution of the state's plan. The presence of that option—and the state's selection, instead, of a plan with less Black electoral opportunity and generally inferior metrics across the traditional principles—is strong evidence of dilutive intent.

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References

[1] Amariah Becker, Moon Duchin, Dara Gold, and Sam Hirsch, *Computational Redistricting and the Voting Rights Act*. **Election Law Journal**, Volume 20, Number 4 (2021), 407–441.

[2] Daryl DeFord, Moon Duchin, and Justin Solomon, *Recombination: A family of Markov chains for redistricting.* **Harvard Data Science Review**, Issue 3.1, Winter 2021.

[3] Gregory Herschlag, Han Sung Kang, Justin Luo, Christy Vaughn Graves, Sachet Bangia, Robert Ravier and Jonathan C. Mattingly, *Quantifying Gerrymandering in North Carolina*. **Statistics and Public Policy**, Volume 7, No. 1 (2020), 30–38.

[4] MGGG Redistricting Lab, *GerryChain Python Library*. GitHub Repository. `github.com/mggg/gerrychain`

[5] South Carolina House of Representatives Judiciary Committee Redistricting Ad Hoc Committee, *2021 Guidelines and Criteria for Congressional and Legislative Redistricting*. `redistricting.schouse.gov/docs/2021 Redistricting Guidelines.pdf`

[6] South Carolina House of Representatives Redistricting 2021, *Public Submissions*. `redistricting.schouse.gov/publicsubmissions`

[7] South Carolina House of Representatives Redistricting 2021, *Public Hearings*. `redistricting.schouse.gov/publichearing`

[8] South Carolina Senate Judiciary Committee Redistricting Subcommittee, *2021 Redistricting Guidelines*. `redistricting.scsenate.gov/docs/Senate Redistricting Guidelines Adopted 9-17-21.DOCX`

[9] South Carolina Senate Judiciary Committee Redistricting Subcommittee, *Senate Plan Proposals*. `redistricting.scsenate.gov/planproposal`

[10] South Carolina Senate Judiciary Committee Redistricting Subcommittee, *Meeting Information*. `redistricting.scsenate.gov/meetinginfo`

A   Generation of ensembles of districting plans

Ensembles of alternative districting plans were made with the open-source Python package GerryChain, which has been publicly available since 2018 [4].

The basic step begins with a graph representing the geographical units of South Carolina, then fuses two districts chosen at random. We draw a random tree (graph with no cycles) that spans the double-district; next, the tree is cut at an edge that creates two complementary balanced pieces, which become the new districts replacing the ones that were fused. The district generation process enforces that every district has population within 1% of ideal district size; if the tree has no cut edge leaving sufficiently balanced pieces, then a new tree is drawn. Contiguity is required throughout, as a consequence of the fact that deleting an edge from a tree always leaves two connected components. Compactness is highly favored throughout this process, because compact districts have far more spanning trees [2].

To choose the random tree, a method called *minimum spanning trees* is employed, using weights that encourage county and subdivision integrity. Within-county edges are given a random weight in $[0, 1]$ while those between counties or county subdivisions receive a weight with a +1 "surcharge." This surcharge is additive, so an edge between different counties and between different divisions have a +2, effectively drawing from $[2, 3]$. I also ran a variant that added a "surcharge" for splitting certain COIs frequently mentioned in the public hearing testimony, as shown below in Figure 13. Supporting selections from the COI testimony have been included in the supplementary sections below.

The random tree is chosen by drawing weights from these intervals and then finding the (typically unique) spanning tree of minimum weight. In addition, when that tree is cut to separate new districts, the algorithm first seeks for a between-county edge as the cut, if it is possible within balance constraints. This promotes the selection of spanning trees that restrict to counties and municipalities in a single connected piece, which will tend to keep counties and municipalities un-split in the districts.

Convergence diagnostics for this kind of process are performed by varying the starting point and the random number seed, as well as by comparing outputs after 10,000 steps to those after 100,000; comparing outputs with and without filters like county/subdivision/COI preservation; and comparing runs with population deviation thresholded at 1% to alternative runs with 2% or 0.5% leeway. Together, these provided me with high confidence that 100,000 steps is enough in this particular districting setting (Congressional districts in South Carolina) to produce stable and reliable statistics. The recombination procedure targets the *spanning tree distribution* on plans. For more information on recombination and convergence heuristics, see especially [2].
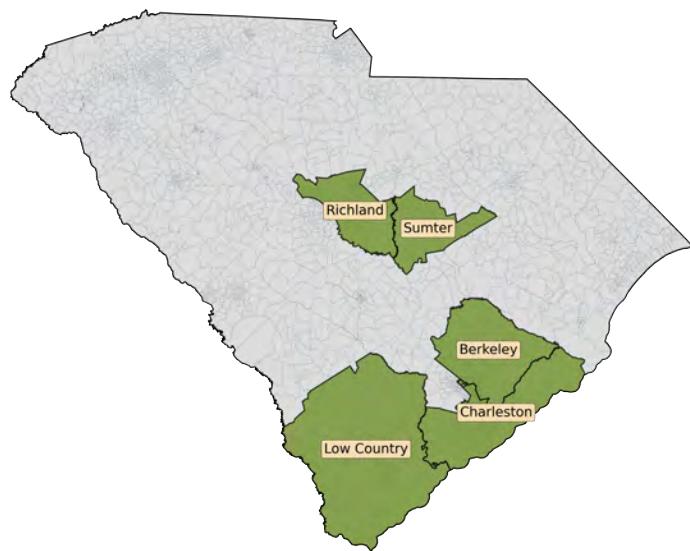
Figure 13: A selection of COIs identified in public testimony. For this report, ensembles were generated both *with* and *without* an emphasis on maintaining these COIs whole. The differences in BVAP and other measurable properties were minimal.

B Selections from public testimony

Below, I have included selections from the public testimony conducted by the South Carolina legislature and available in full at [7, 10]. The Senate public hearings took place July 27-August 12, 2021. The House public hearings were held from September 8-October 4, 2021.

I have organized these by their relevance to the features of CD 1, CD 2, and CD 5 discussed above in Section 5. I have included the speakers' stated affiliations where available.

Jasper County split

Mary Ann Bromley. "The economic importance of the Jasper Port Project is an excellent example of a shared community of interest for residents of both counties in that area."

Dorchester County split illogically

Tim Lewis, Chair of Dorchester County Democratic Party. "So I'd like to look at Dorchester County specifically, because that is our community of interest... Dorchester County I like to call a donor county... We share five senate representatives. And if you look at that map right there, actually, one of those – two of those areas, just little slivers. So what happens is that we donate our voters to other senate districts so they can get their votes. Well, the challenge with that, of course, is that those small slivers do not really truly have true representation. Those senators and so forth live in other districts. They truly are not represented by those folks... But, I mean, we have two senators that represent us well and I think have the interest of the county and our uniqueness of our county, the uniqueness of Summerville, the uniqueness of St. George in their mind, Senator Stephens and Senator Bennett. Those other areas are donors."

Coastal and Lowcountry COIs disregarded.

Blaine Lotz. "In some ways, the formation of today's First Congressional District was a step in the right direction; that is, having Lowcountry counties, such as Charleston and Beaufort, in single district. Unfortunately, your predecessor republicans played politics by carving out the northwestern quadrant of Beaufort County, largely rural, largely African-American, and largely democratic, and moved it into the single majority/minority congressional district, the Sixth, Jim Clyburn's district. The goal was to [dilute] Beaufort County in the First Congressional District keeping it in republican control. The same thing was done in other First District counties, keeping million-dollar beach homes on the coast in the district, but moving their inland working-class neighbors into the Sixth District."

Scott Anderson, Beaufort Federation of Republican Men. "We also currently have representatives that both understand and act on the values that make the Lowcountry special... Our growth, tourism, coastal – the coastal environment, just to name a few. Just as those in the midlands and the upstate have unique needs, I implore the committee to maintain districts that are representative of our diverse state."

Mayor Bill T. Young, Jr. Mayor of Walterboro. "Colleton County is very divided. We have four senators and four representatives, and none of these elected officials are dependent on Colleton County for their elections, so they do what elected officials do, they pay attention to the areas that elect them. We believe that it's Colleton's turn to have a larger portion of its districts, and I would ask you, on behalf of the people of Walterboro and Colleton County, that you keep Colleton County together as much as possible as a community of interest."

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Mayor Steve Murray, Mayor of Beaufort.   "I see Beaufort County as a community of inter-est in terms of our educational challenges, our infrastructure challenges, social and cultural, our historic assets and how we're trying to link those together... [W]hen you look at our chal-lenges around beach erosion, around offshore testing and seismic drilling – seismic testing off of drilling, nesting shorebirds and conservation issues, again, infrastructure around bridges, it is a community of interest as well. So I hope as you're considering drawing those maps, that you would think about Beaufort County as a community of interest and you would think about that coastal district – continue to think about that as a community of interest."

Mayor Tim Goodwin, Mayor of Folly Beach.   "South Carolina's beach communities are relatively few in number and small in population, yet we all face unique challenges that is applicable only to beach communities, and they can be quite large."

Council Member Dickie Schweers, Charleston County Council.   "What I would like to do is specifically address communities of interest, but specifically coastal communities of interest. ... And what I would ask you is to please continue allowing those districts to properly represent those coastal communities. The commonalities I see, because they're coastal districts, include tourism; housing, and especially housing cost; outdoor recreation; port and shipping activity; boating; hunting; fisheries."

Jerry Ashmore, Port Royal Town Council.   "We're a community of interest along the coast. We need to keep coastal communities in a district that share natural resources, beaches, estuaries, and tourism. We're in this together and we all share similar concerns all for the good of the Lowcountry."

Mayor Jane Darby, Mayor of Edisto Beach.   "I want to address a little bit further, the community of interest. We know our community has an odd shape... So what I would like to bring is a few more things in the community of interests for our district. The most important factor to consider, and is vastly more important for the welfare of us, is that we all share the same problems, and it's all related [to] a maritime environment."

Jodie Strutek.   "Here in Beaufort County, we are at a disadvantage because legislators have used our voters as a political football in the drawing of congressional districts and senate districts. It prevents us from being adequately heard by our representation. We've heard the testimony of my peers tonight. Our communities, specifically subcommunities of color, are split into different districts despite being a part of Beaufort County."

Mayra Rivera-Vazquez, Chair of the Beaufort County Democratic Party.   "The Latino community is one of the fastest growing communities in America this decade, and Beaufort County is not an exception. Beaufort County is one of the top five counties with the highest Latino population in the state, with 11.1 percent. Three cities in the county have the largest Latino population in South Carolina, Bluffto with 16.84 percent, Port Royal with 12.55 percent, and Hilton Head with 11.81 percent. The Lowcountry 1st Congressional District has the largest number of Latino voters in South Carolina with 4 percent. As the Senate Subcommittee on Re-districting examines communities of interest as essential criteria to preserving and enhancing the political strength of those communities, the expansion of the Latino population in Beaufort County must be addressed... As South Carolina, we draw lines for electoral district this year. The Latino community in Beaufort County, as a community of interest, cannot afford to sit on the sidelines."

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Council Member Steve Murdaugh, Colleton County County Council.   "I am here speaking on behalf of the citizens of Colleton County... Well, if you want to talk about communities of interest, you already have communities of interest. You have councils of government. We have Lowcountry councils of government. Look at your counties that are there. We're members of the Southern Carolina Economic Development Lines. Look at the counties that are there. We don't have any community ventures with Dorchester or that district. I think that would be a starting point to try to get more of Colleton into a – some of these other districts."

Christine deVries.   "But I actually wanted to speak directly to the issues with Beaufort County. We've had several people before, spoke very well to how we're a vibrant place and full of active citizens and that we all believe that Beaufort County should be a community of interest, and I certainly concur with that.I think it's critical that in our redistricting process, that Beaufort County is preserved and enhanced and ensure we do have strong representation, in both the US Congress and the South Carolina Legislature, and that our representation is not diluted by unnecessarily dividing parts of the county between legislative districts."

Queen Quet (Marquetta L. Goodwine).   "I am very pleased to have this opportunity to speak on behalf of the Gullah/Geechees that reside on the Sea Islands, in particular as a community of interest. I'm a native of St. Helena Island, also with family roots on Polawana Island and Datha Island; and that's here in Beaufort County, South Carolina. But we also have a kinship with Edisto Island... And it's important for us who are natives here to sustain this very environment, because we are inextricably tied to it. I always tell everyone that the land is our family and the waterways are our bloodline. So we're working on a resiliency project with the EPA for St. Helena Island. And we'd love to see that duplicated throughout these sea islands because of sea level rise; we have intense heat; and, of course, as already mentioned, we're in a hurricane zone as it is. So we need to sustain this coastline, and we thank you-all for doing the work that you're doing as coastal representatives that are there, because I see one of my good buddies there that helped stop the offshore drilling. And I want you-all to make sure that you drill down on these communities of interest and don't leave (speaking Gullah) out there, because we be Gullah/Geechee anointed people and we're so glad if I have a chance to be a part of the process and make sure that you're aware of us and that our cultural community is sustained environmentally and culturally."

Mark Hartley.   "I represent the 1st District on the board, and the 1st District is – congressional district is largely coastal. It runs along South Carolina coast from Calibogue Sounds in Jasper County through the coastal portions of Beaufort, Colleton, and Charleston Counties up to the Santee River. As the 1st Congressional District Representative on DNR board, I can attest to the 1st Congressional District is a community of interest. The district's geography and coastal natural resources are unique and some of the most magnificent in the – in the nation... Their community interest arise from their unique geographic and coastal natural resources. They border the Atlantic Ocean with a chain of barrier isles. They have extensive saltwater river – river-run estuaries extending far inland. Virtually all coastal tidelands of South Carolina, which are extremely important for water fowl and other endangered species, are in these two senate districts. They have over 70 miles of protected coastline and over a half million protected acres in the Ace Basin, Cape Romain Wildlife Refuge, Santee Delta, and Winyah Bay."

Meade Dillon.   "I am blessed by God to live in what I call the Lowcountry. Yes, I am in Mt. Pleasant; but I can be at the beach in about 15 or 20 minutes, I can be downtown in historic Charleston in about 15 or 20 minutes, or I can be heading up to Moncks Corner or Lake Marion to visit friends on the lake up there, all in a relatively short period of time. And so many of the previous speakers have focused on, oh, Mt. Pleasant, it's a community. Well, guess what? It is not a bubble and I don't stay in it and I think most of those others speakers don't stay in

Mt. Pleasant as well. And so my point is very simple. Senators who have a little piece of Mt. Pleasant and a little piece of the barrier islands and a little piece of the inland, they're going to reflect my community and my interests because they're going to get the whole picture. We have a great variety here in Charleston and in Berkeley and Dorchester County, and so having representatives which have a little piece of all those will help make sure that they really understand the value of living here in the Lowcountry."

William Walker.   "What I'm very worried about is a major part of our life blood here in South Carolina and the Lowcountry is the Gullah-Geechee community, and we must be sure that we take care of those communities and that we make sure that the candidates have a shot at nominating and voting for candidates that are going to support interest of the Gullah-Geechee community as well as the African-American community."

Timothy Wyld.   "I live in Sun City, which should be in the dictionary as the definition of a community of interest. Unfortunately, I live on the north side of Sun City, and even the map that your wonderful cartographer has drawn over there does not recognize our little section of Sun City that is in James Clyburn's district. We are not contiguous with any county other than Beaufort. We are totally surrounded by Beaufort County. We can't have conversations with our neighbors, our friends, our gym partners, our tennis partners, our golf partners because they all vote in CD1 and we're stuck voting in CD6. It makes absolutely no sense. You can go by any of the criteria you're using, we're a community of interest. We have been set apart because Pulte annexed us to the City of Hardeeville to get lower development costs, and we got stuck in Jasper County as a result. I'm begging you to fix this oversight. It just doesn't make sense."

Representative Jermaine Johnson.   "It absolutely makes no sense whatsoever that, you know, we have somebody representing up here that's, you know, down in Charleston or somebody that's in Charleston is representing somebody in Columbia or somebody way down in Edgefield and Aiken and you've got to come down here. This makes no sense."

Michael Sawiki.   "I would like to speak to the Committee about the natural geography sometimes connected by water, sometimes connected by land that we along the shore of South Carolina Coast. There is no question that this is one of the most beautiful and pristine environments in the nation. It is a special place because of the many rivers that flow through the marshlands into the sea. These rivers and marshes are alive with hundreds of varieties of fish, shellfish, shrimp, animals and birds of all kind. Many of the creatures that live in the deeper oceans began their lives in the South Carolina marshes and rivers. Some of [] us who live in this beautiful part of the state were fortunate enough to be born here. And many of us came here because of the natural beauty. I think that I speak for most of us who know the importance of protecting the preserve – and preserving what we have here... because elected officials who live and work along the Coast share a common love and understanding for the area and those of us whole live here, we would like to see the Low Country be treated as a community of interest when the redistricting takes place."

Willie Terrell, Young Republicans of Beaufort County.   "But in a way, I feel like I represent many young people throughout the Low Country. Because up and down the South Carolina coast, our needs, our wants, our aspirations are much of the same. Many of us, like myself, were born and raised in the Low Country. We love it. We like to make it our home and raise our family here. In order to do so we need two things: One, quality education, and, two, opportunities."

Council Member Logan Cunningham, Beaufort County Council and Vice President of the Republican Club. "But I will tell you that the representatives that we've had for this time, or our new representatives, the policies that are put in place here for Beaufort County and the Low Country have made it a desirable and successful place for people to continue to come to... It's about the fact that the values and the conservative policies that we've had here in the Low Country, that have made it successful... We stand here in Beaufort County with our Low Country values. And we're prepared to continue to defend them, because they have been successful here and in the state."

Charleston County split erratically

A.J. Davis. "I live in the southern end of North Charleston right outside of the old Naval base. I consider my community of interest not only that geographic area, but the marginalized African-American populations, both native and adopted, or in local terms, the benyas and the comeyas. I've called Charleston home for the last 20 years... I live in the Chicora Community but share a kindred spirit with most of the southern end of North Charleston south of Park Circle. Like many of the folks who have come before me, I express concern that this process will afford marginalized communities such as mine legitimate, effective political representation. As Ms. Singleton so eloquently put it, it's about more than votes, but the impact to human lives. Due to population changes, communities like mine were havens for members of the African-American populations that have been displaced due to [gentrification], specifically from areas like downtown and West Ashley."

Kelly Gorby. "I'm glad the one gentleman bought up the maps of Charleston County, because as far as the U.S. Congressional District is concerned, that shape is crazy. Charleston County deserved to be in one U.S. Congressional District. North Charleston problems, North Charleston interests should be considered with the rest of Charleston County and not with Columbia. That's where our airport is. That's where our tourists are coming into town. They're sleeping in those hotels. They're shopping at Tanger Outlets. There's really no reason that they shouldn't be considered in our same U.S. Congressional District. So I would also advocate for that."

Emily Mayer.   "First, I would like to start with our congressional district lines. Beaufort County is currently split among two different congressional districts... As the population of Beaufort County is well within the limits of what a congressional district can hold, I implore you to find out why this section of Beaufort County has been cut out of being represented by the same congressperson as the rest of their county members, as we are a part of the same community with interests regarding our public educational system. Additionally, Congressional District 1 extends up the shores through Charleston County. But, as you can see on the map, it cuts out North Charleston and then goes in again to Berkeley County. Again, noting that that North Charleston demographic is overwhelming[ly] less white compared to the areas of Charleston and Berkeley Counties that are included in Congressional District 1 all the way to Monks Corner, all the way up in that Berkeley County area, which is 68 percent white. I ask again why this cutout is necessary? If we're talking about continual lines, the shapes of our district, why not make it more continuous to allow communities of the same counties to stay together? These lines don't feel as if they meet the requirements needed... I add to the sentiments that were made earlier that Beaufort County is a community of interest within itself."

Brady Quirk-Garvan.   "Charleston and the broader tri-county have seen tremendous growth in the last decade and,despite the global pandemic, it shows no signs of slowing down... Keeping neighborhoods [and] geographic zones together are important not only because it

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allows constituents to know their representatives, but because it allows for greater economic progress. When Senators and House members draw elongated districts and stretch districts across rivers, oceans, and county lines, it creates problems when it comes to advocacy for district. It is difficult to be the best advocate for your constituents when a district involves multiple counties and widely different geographic areas. The needs of a dense suburb like Mt. Pleasant and Charleston County are very different from rural Berkeley County, and sometimes their needs are antithetical to one another; and yet we have districts where senators are asked to provide the same level of advocacy to both, and that just doesn't happen. Another example of this is my congressional district, District 6, which runs from here in North Charleston up to Columbia. And I can assure you, living here, that North Charleston is much more intertwined with Charleston and the Lowcountry than it is with the Midlands."

David Quick.   "So the slicing and dicing, it ultimately comes down to this gerrymandering stuff... We need our – our congressional district not to stretch all the way down. We've got three hubs on the coast and, let's face it, the coast is one of our big drivers of South Carolina's economy. You've got – you've got the Grand Strand, you've got Charleston, and you've got Hilton Head and Beaufort. These are very distinct hubs. Let's try to think along those hub lines, you know, and those natural boundaries. And, really, let's make – let's make these lines make sense and not confuse voters anymore... And just like so many people said, people in North Charleston have more in common with people in Charleston than they do in Columbia."

Zachary Kronsberg.   " I agree with what Mr. Quirk-Garvan said earlier about North Charleston and, frankly, half of downtown having more in common with the rest of Charleston County than they do with Columbia. So I think that it would make sense for them to be in the U.S. Congressional 1st District instead of the 6th District."

Shayna Howell.   "I urge you to consider [Charleston] county a community of interest and not split it so many ways...While I appreciate the idea of the coast as a group of residents with shared interests, I believe we would be better served by districts that don't split so many county lines – residents of these coastal counties typically all care about our coastal resources – so their voice will not be diluted."

Emmett Robert Murray Jr.   "Where did the input for this ridiculous change come from? Was a blindfold and dart board involved? I have read a [] good deal about gerrymandering, but this is my first time at seeing it up close and personal. I'm sure that this map that I am looking at showing this oddball projection protruding into district 1 must be a misdirected key punch. It is beyond belief that state bean counters have decided that the interest of the West Ashley residents of Charleston Co. and the people of the rural counties of Clarendon, Orangeburg and Darlington are anywhere close to similar. This political anomaly needs to be corrected before it is set in stone."

Lynn Schuler Teague, League of Women Voters South Carolina.   "The League plan accurately reflects the diverse population is what is increasingly a network of closely tied satellite communities around a center in urban Charleston. The League proposal shows that much of this important community of interest could easily be kept together in CD 1. The Senate's [draft] map, on the other hand, produces what in our measure is a 14-percentage point partisan gap by slicing and dicing this clear community of interest in unreasonable ways. Charleston itself is split. Adjacent North Charleston would continue to be put into a district with Columbia, more than a hundred miles away, although it is very much a part of the social and economic networks associated with Charleston. James Island and Johns Island would be split. What would the people of South Carolina sacrifice so that the General Assembly can achieve this gerrymander?"

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Gloria Aslanidis.   "My home is in the City of Charleston and the County of Charleston.... I'm sure Dorchester County is a lovely place to live, but I see no community of interest."

Orangeburg separated from CD 2

Chester Palmer.   "[Orangeburg County has] much more in common with Columbia and Richland and Lexington than we do with Charleston. And that's something that you need to consider when you redraw the district lines."

Larry Wagner.   "Now, what do those folks down in the tail of Georgia have to do – a commonality with Orangeburg-Calhoun County where we live in St. Matthews?"

State Representative Jerry Govan.   "The redistricting process should incorporate more of the City of Orangeburg and more of the nearby suburbs, considering the history of this district... The City of Orangeburg and surrounding areas in Central Orangeburg County should continue to have a voice in their respective areas."

Hook around Columbia

William Maxie.   "And so when you go to redistrict this time – and there's been a lot of growth in South Carolina, and y'all have to make a lot of changes – I would urge you to make sure that these districts are fair, obviously, and equitable, but make sure that they make sense geometrically... I mean, you know, the 2nd District is a good example where Representative Wilson is. I mean, it reaches around the City of Columbia, and to what end is that? I mean, do people in downtown Columbia not have that much in common with people from Forest Acres or people right across the river? No, they do. That's where a lot of those people live and a lot of those people work, so, you know, the shape of these districts is important, and y'all really need to make sure that towns and counties stay whole to make sure that our communities of interest are represented. That's not just a legal term. That's just the people that we live with and work with, that we worship with and that we spend all of our time with."

Splitting in and around Columbia

Jonnieka Farr, Co-chair of Columbia Branch of NAACP Political Action Committee and Chair Richland County Democratic Women's Council.   "I live in the Northeast Columbia area...I would like for the redistricting committee to ensure that redistricting is not done in such a way that arbitrary lines are drawn splitting neighborhoods"

Lynn Schuler Teague.   "CD 2 should not have a finger projecting through Columbia. In Richland County, the effort to get CD 2 to Fort Jackson drives CD 2 through the Black communities of northwest Richland, separating them from neighboring communities to allow the incumbent to "keep" Fort Jackson within "his" district. Why must a legislator have a specific base within his district to protect it in deliberations of the House Armed Services Committee? Also, how does an incumbent's interest constitute a community of interest-especially where it requires violating a clear and very real community of interest of minority voters?"

Sumter COI is not respected

Archie Parnell.   "And here we are in Sumter and Sumter is split down the middle. The historic district where I live, three blocks down is a different congressional district. Two blocks up is a different congressional district... And I think there is a community of interest here in

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Sumter and I would urge you to continue with your criteria that you've adopted 10 years ago and, hopefully, keep counties together. Now, I realize that these various criteria are not all in one direction. Sometimes they conflict with each other and so you cannot just always have a win/win on everything. But I would urge you that the lines that are drawn in Sumter be redrawn in order to make it more of a unit, more of a community of interest."

John Reilly.   "I'm not in a big populated area, but everything else I do is in Sumter. And everything that people in my neighborhood do is in Sumter. We're attached to Shaw, so that's kind of how we – everything is Sumter oriented, but our representation, if I have anything to say to anybody, is in Richland. Which really doesn't make any sense for us."

Anthony Nyser.   "So like I was saying, I've only been a resident of South Carolina, namely Sumter, for a couple of years. The first two years I lived in town was normal. And then when I bought a home at the beginning of this year, I'm wanting to say it's about a three mile difference between the old home and the new home, but I have a completely different representation at all levels. And that's something that was really concerning to me because I still shop at the same Piggly Wiggly. Everyone is Sumter still goes to the same one Starbucks. We all have very, very aligned interests, lifestyles. There's some obvious socioeconomic differences in town, but it's still one town, one community."

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I reserve the right to continue to supplement my report in light of additional facts, testimony and/or materials that may come to light. Pursuant to 28 U.S.C. 1746, I declare under penalty of perjury of the laws of the United States that the foregoing is true and correct according to the best of my knowledge, information, and belief.

Executed this 11th day of April, 2022.

Moon Duchin

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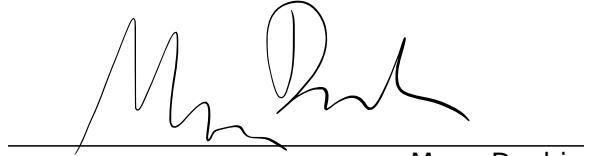
Moon Duchin

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Mathematics · STS · Tisch College of Civic Life | Tufts University

Education

University of Chicago   MS 1999, PhD 2005
Mathematics
Advisor: Alex Eskin   Dissertation: *Geodesics track random walks in Teichmüller space*

Harvard University   BA 1998
Mathematics and Women's Studies

Appointments

Tufts University
Professor of Mathematics   2021—
    Assistant Professor, Associate Professor   2011–2021

Principal Investigator │ MGGG Redistricting Lab   2017—

Senior Fellow │ Jonathan M. Tisch College of Civic Life   2017—

Director │ Program in Science, Technology, & Society   2015–2021

University of Michigan
Assistant Professor (postdoctoral)   2008–2011

University of California, Davis
NSF VIGRE Postdoctoral Fellow   2005–2008

Research Interests

Data science for civil rights, computation and governance, elections, geometry and redistricting.
Science, technology, and society, science policy, census data, technology and law, algorithmic fairness.
Random walks and Markov chains, random groups, random constructions in geometry.
Large-scale geometry, metric geometry, isoperimetric inequalities.
Geometric group theory, growth of groups, nilpotent groups, dynamics of group actions.
Geometric topology, hyperbolicity, Teichmüller theory.

Selected Awards & Distinctions

Research Professor - MSRI Program in Analysis and Geometry of Random Spaces	Spring 2022
Guggenheim Fellow	2018
Radcliffe Fellow - Evelyn Green Davis Fellowship	2018–2019
Fellow of the American Mathematical Society	elected 2017
NSF C-ACCEL (PI) - Harnessing the Data Revolution: Network science of Census data	2019–2020
NSF grants (PI) - CAREER grant and three standard Topology grants	2009–2022
Professor of the Year, Tufts Math Society	2012–2013
AAUW Dissertation Fellowship	2004–2005
NSF Graduate Fellowship	1998–2002
Lawrence and Josephine Graves Prize for Excellence in Teaching (U Chicago)	2002
Robert Fletcher Rogers Prize (Harvard Mathematics)	1995–1996

Applied and Interdisciplinary Publications & Preprints

Political Geometry: Rethinking Redistricting in the U.S. with Math, Law, and Everything In Between
25 chapters, 475 pages. Preprint online. Birkhäuser Books, to appear 2022. (eds. Moon Duchin, Olivia Walch)
see: Introduction, Compactness, Communities of Interest, Clustering, Random Walks, Ranked Choice Voting.

Private numbers in public policy: Census, differential privacy, and redistricting
Harvard Data Science Review, to appear 2022. (with Aloni Cohen, JN Matthews, and Bhushan Suwal)

The (homological) persistence of gerrymandering
Foundations of Data Science, to appear 2022. Online first. (with Thomas Needham and Thomas Weighill)

Implementing partisan symmetry: Problems and paradoxes
Political Analysis, to appear 2022. arXiv:2008:06930
(with Daryl DeFord, Natasha Dhamankar, Mackenzie McPike, Gabe Schoenbach, and Ki-Wan Sim)

Measuring segregation via analysis on graphs
Preprint. arXiv:2212.10708 (with James Murphy and Thomas Weighill)

A reversible recombination chain for graph partitions
Preprint. (with Sarah Cannon, Dana Randall, and Parker Rule)

Ranked choice voting and minority representation
Preprint. Online. (with Gerdus Benade, Ruth Buck, Dara Gold, and Thomas Weighill)

Clustering propensity: A mathematical framework for measuring segregation
Preprint. (with Emilia Alvarez, Everett Meike, and Marshall Mueller; appendix by Tyler Piazza)

Discrete geometry for electoral geography
Preprint. (with Bridget Eileen Tenner)   arXiv:1808.05860

Recombination: A family of Markov chains for redistricting
Harvard Data Science Review. Issue 3.1, Winter 2021. Online. (with Daryl DeFord and Justin Solomon)

Census TopDown: The impact of differential privacy on redistricting
2nd Symposium on Foundations of Responsible Computing (FORC 2021), 5:1–5:22. Available online.
(with Aloni Cohen, JN Matthews, and Bhushan Suwal)

Models, Race, and the Law
Yale Law Journal Forum, Vol. 130 (March 2021). Available online. (with Doug Spencer)

Computational Redistricting and the Voting Rights Act
Election Law Journal, Volume 20, Number 4 (2021), 407–441. Available online.
(with Amariah Becker, Dara Gold, and Sam Hirsch)

Mathematics of nested districts: The case of Alaska
Statistics and Public Policy. Vol 7, No 1 (2020), 39–51. (w/ Sophia Caldera, Daryl DeFord, Sam Gutekunst, & Cara Nix)

A computational approach to measuring vote elasticity and competitiveness
Statistics and Public Policy. Vol 7, No 1 (2020), 69–86. (with Daryl DeFord and Justin Solomon)

Locating the representational baseline: Republicans in Massachusetts
Election Law Journal, Volume 18, Number 4, 2019, 388–401.
(with Taissa Gladkova, Eugene Henninger-Voss, Ben Klingensmith, Heather Newman, and Hannah Wheelen)

Redistricting reform in Virginia: Districting criteria in context
Virginia Policy Review, Volume XII, Issue II, Spring 2019, 120–146. (with Daryl DeFord)

Geometry v. Gerrymandering
The Best Writing on Mathematics 2019, ed. Mircea Pitici. Princeton University Press.
reprinted from Scientific American, November 2018, 48–53.

Gerrymandering metrics: How to measure? What's the baseline?
Bulletin of the American Academy for Arts and Sciences, Vol. LXII, No. 2 (Winter 2018), 54–58.

Rebooting the mathematics of gerrymandering: How can geometry track with our political values?
The Conversation (online magazine), October 2017. (with Peter Levine)

A formula goes to court: Partisan gerrymandering and the efficiency gap
Notices of the American Mathematical Society **64** No. 9 (2017), 1020–1024. (with Mira Bernstein)

International mobility and U.S. mathematics
Notices of the American Mathematical Society **64**, No. 7 (2017), 682–683.

Pure Mathematics Publications & Preprints

Conjugation curvature for Cayley graphs
Journal of Topology and Analysis, to appear 2022. Online first. (with Assaf Bar-Natan and Robert Kropholler)

You can hear the shape of a billiard table: Symbolic dynamics and rigidity for flat surfaces
Commentarii Mathematici Helvetici, Vol 96, Issue 3 (2021), 421–463. Available online.
(with Viveka Erlandsson, Christopher Leininger, and Chandrika Sadanand)

Stars at infinity in Teichmüller space
Geometriae Dedicata, Volume 213, 531–545 (2021). (with Nate Fisher)   arXiv:2004.04321

The Heisenberg group is pan-rational
Advances in Mathematics **346** (2019), 219–263. (with Michael Shapiro)

Random nilpotent groups I
International Mathematics Research Notices, Vol. 2018, Issue 7 (2018), 1921–1953.
(with Matthew Cordes, Yen Duong, Meng-Che Ho, and Ayla Sánchez)

Hyperbolic groups
chapter in *Office Hours with a Geometric Group Theorist*, eds. M.Clay,D.Margalit, Princeton U Press (2017), 177–203.

Counting in groups: Fine asymptotic geometry
Notices of the American Mathematical Society **63**, No. 8 (2016), 871–874.

A sharper threshold for random groups at density one-half
Groups, Geometry, and Dynamics **10**, No. 3 (2016), 985–1005.
(with Katarzyna Jankiewicz, Shelby Kilmer, Samuel Lelièvre, John M. Mackay, and Ayla Sánchez)

Equations in nilpotent groups
Proceedings of the American Mathematical Society **143** (2015), 4723–4731. (with Hao Liang and Michael Shapiro)

Statistical hyperbolicity in Teichmüller space
Geometric and Functional Analysis, Volume 24, Issue 3 (2014), 748–795. (with Howard Masur and Spencer Dowdall)

Fine asymptotic geometry of the Heisenberg group
Indiana University Mathematics Journal 63 No. 3 (2014), 885–916. (with Christopher Mooney)

Pushing fillings in right-angled Artin groups
Journal of the LMS, Vol 87, Issue 3 (2013), 663–688. (with Aaron Abrams, Noel Brady, Pallavi Dani, and Robert Young)

Spheres in the curve complex
In the Tradition of Ahlfors and Bers VI, Contemp. Math. **590** (2013), 1–8. (with Howard Masur and Spencer Dowdall)

The sprawl conjecture for convex bodies
Experimental Mathematics, Volume 22, Issue 2 (2013), 113–122. (with Samuel Lelièvre and Christopher Mooney)

Filling loops at infinity in the mapping class group
Michigan Math. J., Vol 61, Issue 4 (2012), 867–874. (with Aaron Abrams, Noel Brady, Pallavi Dani, and Robert Young)

The geometry of spheres in free abelian groups
Geometriae Dedicata, Volume 161, Issue 1 (2012), 169–187. (with Samuel Lelièvre and Christopher Mooney)

Statistical hyperbolicity in groups
Algebraic and Geometric Topology **12** (2012) 1–18. (with Samuel Lelièvre and Christopher Mooney)

Length spectra and degeneration of flat metrics
Inventiones Mathematicae, Volume 182, Issue 2 (2010), 231–277. (with Christopher Leininger and Kasra Rafi)

Divergence of geodesics in Teichmüller space and the mapping class group
Geometric and Functional Analysis, Volume 19, Issue 3 (2009), 722–742. (with Kasra Rafi)

Curvature, stretchiness, and dynamics
In the Tradition of Ahlfors and Bers IV, Contemp. Math. **432** (2007), 19–30.

Geodesics track random walks in Teichmüller space
PhD Dissertation, University of Chicago 2005.

Teaching

Courses Developed or Customized

Mathematics of Social Choice | sites.tufts.edu/socialchoice
Voting theory, impossibility theorems, redistricting, theory of representative democracy, metrics of fairness.
Have designed and taught variants at entry level and at math-major level.

History of Mathematics | sites.tufts.edu/histmath
Social history of mathematics, organized around episodes from antiquity to present. Themes include materials and technologies of creation and dissemination, axioms, authority, credibility, and professionalization. In-depth treatment of mathematical content from numeration to cardinal arithmetic to Galois theory.

Reading Lab: Mathematical Models in Social Context | sites.tufts.edu/models
One hr/wk discussion seminar of short but close reading on topics in mathematical modeling, including history of psychometrics; algorithmic bias; philosophy of statistics; problems of model explanation and interpretation.

Reading Lab: Classification | sites.tufts.edu/classification
One hr/wk discussion seminar of short but close reading on topics in classifications and taxonomies, including censuses; race and ethnicity; academic disciplines, mathematical and legal definition; chemical elements; species and model organisms; sex and gender.

Geometric Literacy
Module-based graduate topics course. Modules have included: p-adic numbers, hyperbolic geometry, nilpotent geometry, Lie groups, convex geometry and analysis, the complex of curves, ergodic theory, the Gauss circle problem.

Markov Chains (graduate topics course)
Teichmüller Theory (graduate topics course)
Fuchsian Groups (graduate topics course)
Continued Fractions and Geometric Coding (undergraduate topics course)
Mathematics for Elementary School Teachers (inquiry-based course for pre-service teachers)

Standard Courses

Mathematical Modeling and Computation (with Python), Discrete Mathematics, Calculus I-II-III, Intro to Proofs, Linear Algebra, Complex Analysis, Differential Geometry, Abstract Algebra, Graduate Real Analysis

Weekly Seminars Organized

- Geometric Group Theory and Topology
- Science, Technology, and Society Lunch Seminar

Selected Talks and Lectures
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AMS Einstein Public Lecture in Mathematics   October 2023
Central Sectional Meeting of the AMS, Omaha, NE

Distinguished Plenary Lecture   June 2021
75th Anniversary Meeting of Canadian Mathematical Society, Ottawa, Ontario   *online (COVID)*

BMC/BAMC Public Lecture   April 2021
Joint British Mathematics/Applied Mathematics Colloquium, Glasgow, Scotland   *online (COVID)*

Radcliffe Fellow Lecture
Radcliffe Institute for Advanced Study, Cambridge, MA   November 2018

Gerald and Judith Porter Public Lecture
AMS-MAA-SIAM, Joint Mathematics Meetings, San Diego, CA   January 2018

Mathematical Association of America Distinguished Lecture
MAA Carriage House, Washington, DC   October 2016

American Mathematical Society Invited Address
 AMS Eastern Sectional Meeting, Brunswick, ME   September 2016

Named University Lectures

  - Loeb Lectures in Mathematics │ Washington University in St. Louis   April 2022
  - Mathematics and Natural Sciences Divisional Lecture │ Reed College   March 2022
  - Parsons Lecture │ UNC Asheville   October 2020
  - Math, Stats, CS, and Society │ Macalester College   October 2019
  - MRC Public Lecture │ Stanford University   May 2019
  - Freedman Memorial Colloquium │ Boston University   March 2019
  - Julian Clancy Frazier Colloquium Lecture │ U.S. Naval Academy   January 2019
  - Barnett Lecture │ University of Cincinnati   October 2018
  - School of Science Colloquium Series │ The College of New Jersey   March 2018
  - Kieval Lecture │ Cornell University   February 2018
  - G. Milton Wing Lectures │ University of Rochester   October 2017
  - Norman Johnson Lecture │ Wheaton College   September 2017
  - Dan E. Christie Lecture │ Bowdoin College   September 2017

Math/Computer Science Department Colloquia

  - Reed College   Dec 2020   - Université de Neuchâtel   Jun 2016
  - Georgetown (CS)   Sept 2020   - Brandeis University   Mar 2016
  - Santa Fe Institute   July 2020   - Swarthmore College   Oct 2015
  - UC Berkeley   Sept 2018   - Bowling Green   May 2015
  - Brandeis-Harvard-MIT-NEU   Mar 2018   - City College of New York   Feb 2015
  - Northwestern University   Oct 2017   - Indiana University   Nov 2014
  - University of Illinois   Sept 2017   - the Technion   Oct 2014
  - University of Utah   Aug 2017   - Wisconsin–Madison   Sept 2014
  - Wesleyan   Dec 2016   - Stony Brook   March 2013
  - Worcester Polytechnic Inst. Dec 2016

Minicourses

- Integer programming and combinatorial optimization (two talks) | Georgia Tech   May 2021
- Workshop in geometric topology (main speaker, three talks) | Provo, UT   June 2017
- Growth in groups (two talks) | MSRI, Berkeley, CA   August 2016
- Hyperbolicity in Teichmüller space (three talks) | Université de Grenoble   May 2016
- Counting and growth (four talks) | IAS Women's Program, Princeton   May 2016

Visiting Lectures

- Election Law | Yale Law School   Spring 2022
- Election Law | Harvard Law School   Spring 2022
- Privacy, Policy, and the U.S. Census | University of Chicago (CS)   Spring 2022
- Optimized Democracy | Harvard (CS)   Spring 2021

Science, Technology, and Society

- The Mathematics of Accountability | Sawyer Seminar, Anthropology, Johns Hopkins   February 2020
- STS Circle | Harvard Kennedy School of Government   September 2019
- Data, Classification, and Everyday Life Symposium | Rutgers Center for Cultural Analysis   January 2019
- Science Studies Colloquium | UC San Diego   January 2019
- Arthur Miller Lecture on Science and Ethics | MIT Program in Science, Tech, and Society   November 2018

Data Science, Computer Science, Quantitative Social Science

- Can Algorithms Bend the Arc Towards Fairness? | Algorithmic Justice Project, UNM/SFI   March 2022
- Data Linkage Seminar | Massive Data Institute, McCourt School of Public Policy   August 2021
- Mechanism Design for Social Good (MD4SG) Colloquium | MD4SG Initiative   November 2020
- Data Science for Social Good (DS4SG) Workshop | Georgia Tech   November 2020
- Privacy Tools Project Retreat | Harvard   May 2020
- Women in Data Science Conference | Microsoft Research New England   March 2020
- Quantitative Research Methods Workshop | Yale Center for the Study of American Politics   February 2020
- Societal Concerns in Algorithms and Data Analysis | Weizmann Institute   December 2018
- Quantitative Collaborative | University of Virginia   March 2018
- Quantitative Social Science | Dartmouth College   September 2017
- Data for Black Lives Conference | MIT   November 2017

Political Science, Geography, Law, Democracy, Fairness

- The Long 19th Amendment: Women, Voting, and American Democracy | Radcliffe Institute   Nov–Dec 2020
- "The New Math" for Civil Rights | Social Justice Speaker Series, Davidson College   November 2020
- Math, Law, and Racial Fairness | Justice Speaker Series, University of South Carolina   November 2020
- Voting Rights Conference | Northeastern Public Interest Law Program   September 2020
- Political Analysis Workshop | Indiana University   November 2019
- Program in Public Law Panel | Duke Law School   October 2019
- Redistricting 2021 Seminar | University of Chicago Institute of Politics   May 2019
- Geography of Redistricting Conference Keynote | Harvard Center for Geographic Analysis   May 2019
- Political Analytics Conference | Harvard University   November 2018
- Cyber Security, Law, and Society Alliance | Boston University   September 2018
- Clough Center for the Study of Constitutional Democracy | Boston College   November 2017
- Tech/Law Colloquium Series | Cornell Tech   November 2017
- Constitution Day Lecture | Rockefeller Center for Public Policy, Dartmouth College   September 2017

Program Development

Principal Investigator MGGG Redistricting Lab   mggg.org

Multidisciplinary research lab with postdocs, research staff, and undergraduate researchers drawn from mathematics, computer science, software development, geography, policy. Hosts law student externs. Provided public mapping support for roughly 100 localities after 2020 Census data released.

Support includes NSF Convergence Accelerator, Sloan Foundation, Thornburg Foundation, Arnold Foundation.

Co-Founder, Program Director Science, Technology, and Society Program   sts.tufts.edu
Interdisciplinary program offering a major and minor, with $\sim$40 affiliated faculty. Runs popular weekly lunch seminar, Reading Labs on topics from Automation to Representation to Life to Energy.

Organizer Semester Program in *Algorithms, Fairness, and Equity*, Fall 2023
Mathematical Sciences Research Institute, Berkeley CA

Program will host $\sim$50 research members on topics connected to mechanism design, fair partitioning, and fair ML.

Designer Short workshops and training programs

- GeoData Bootcamp 2020 (20 students from around the country)
- Mapping Training 2020 (30 students from around the country)
- Graphs and Networks Workshop 2020 (500 live participants)
- Data for Election Administration online 2021, in-person 2019 (dozens of administrators and scholars)

Program builder Research and mentorship programs

- Voting Rights Data Institute 2018, 2019
  Six-week summer research programs hosting 52 and 33 undergraduate and graduate students, respectively, with dozens of visitors from math, CS, law, political science, geography, urban planning, and more.
- Polygonal Billiards Research Cluster 2017, Random Groups Research Cluster 2014
  Five-week intensive summer research programs for vertically integrated groups of 12-14 undergraduate, graduate, postdoctoral, and junior faculty researchers, combining experimental and theoretical work.
- Directed Reading Program and DRP Network   sites.google.com/view/drp-network/
  Co-founded highly successful near-peer mentoring program in 2003 at UChicago. Now exists at $>$40 math departments as grad-student-run reading program with excellent outcomes for broadening participation in mathematics. Secured NSF grant to expand the program to more campuses and to fund social science research on outcomes.

Graduate Advising in Mathematics

Nate Fisher (PhD 2021),   Sunrose Shrestha (PhD 2020),   Ayla Sánchez (PhD 2017),
Kevin Buckles (PhD 2015),   Mai Mansouri (MS 2014)

Outside committee member for Chris Coscia (PhD 2020), Dartmouth College

Postdoctoral Advising in Mathematics

Principal supervisor Thomas Weighill (2019–2020)

Co-supervisor Daryl DeFord (MIT 2018–2020), Rob Kropholler (2017–2020), Hao Liang (2013–2016)

Selected Professional Service and Public-Facing Work

Program committees and editorial boards
ACM Conference on Fairness, Accountability, and Computing (FAccT)   2022
Symposium on Foundations of Responsible Computing (FORC)   2021
Harvard Data Science Review   since 2019
Advances in Mathematics   since 2018

Committee on Science Policy   2020–2022
American Mathematical Society

Amicus Brief of Mathematicians, Law Professors, and Students   2019
principal co-authors: Guy-Uriel Charles and Moon Duchin

Supreme Court of the United States, in Rucho v. Common Cause - cited in dissent

Expert work for redistricting litigation   2018—
reports, deposition, and/or trial testimony

Pennsylvania, North Carolina, Wisconsin, South Carolina, Alabama

Presenter on Public Mapping, Statistical Modeling   2019, 2020
National Conference of State Legislatures

Committee on The Future of Voting: Accessible, Reliable, Verifiable Technology   2017–2018
National Academies of Science, Engineering, and Medicine

Committee on the Human Rights of Mathematicians   2016–2019
American Mathematical Society

Selected Visiting Positions and Residential Fellowships

Research Professor Analysis and Geometry of Random Spaces program   Spring 2022
Mathematical Sciences Research Institute | Berkeley, CA

Visiting Professor Department of Mathematics   Fall 2021
Boston College | Chestnut Hill, MA

Fellow Radcliffe Institute for Advanced Study   2018–19
Harvard University | Cambridge, MA

Member Center of Mathematical Sciences and Applications   2018–19
Harvard University | Cambridge, MA

Visitor Microsoft Research   2018–19
MSR New England | Cambridge, MA

Research Member Geometric Group Theory program   Fall 2016
Mathematical Sciences Research Institute | Berkeley, CA

Research Member Random Walks and Asymptotic Geometry of Groups program   Spring 2014
Institut Henri Poincaré | Paris, France